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Date of mailing (day/month/year) 04 April 2001 (04.04.01)	
International application No. PCT/FI00/00400	**Applicant's or agent's file reference** 49990
International filing date (day/month/year) 05 May 2000 (05.05.00)	**Priority date** (day/month/year) 05 May 1999 (05.05.99)
Applicant NIEMI, Antti	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

04 December 2000 (04.12.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :
G01N 21/85, B03B 13/02

A1

(11) International Publication Number: WO 00/68672

(43) International Publication Date: 16 November 2000 (16.11.00)

(21) International Application Number: PCT/FI00/00400

(22) International Filing Date: 5 May 2000 (05.05.00)

(30) Priority Data:
991023 5 May 1999 (05.05.99) FI

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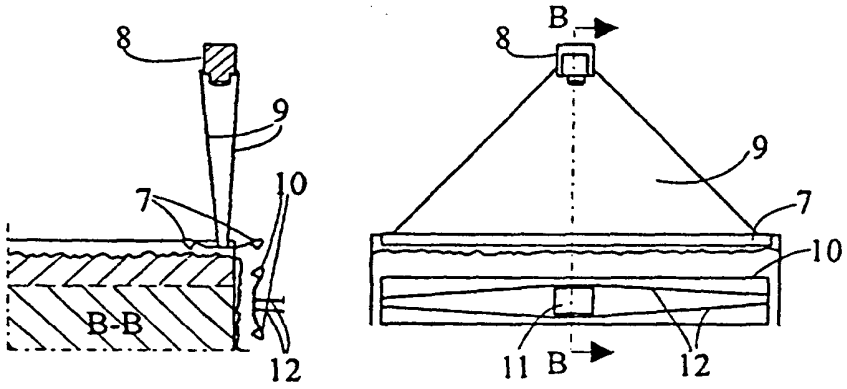
(81) Designated States: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Finnish).

(54) Title: METHOD AND APPARATUS FOR MONITORING AND ANALYZING THE SURFACE OF FLOATED MATERIAL



(57) Abstract

At the separation of different minerals from the ores by means of flotation, it belongs to known art to monitor a larger part of the uppermost froth layer in the flotation cell by means of a video camera whose signals are analyzed in a digital computer, in order to detect the structure and color of the froth. The new method and apparatus direct and limit the monitoring and analysis to the surface of the floated material within a fixed, narrow strip which is parallel to the overflow edge of the cell and within which the material surface passing it is homogeneous in the stationary state. The said strip thus presents a renewing sample of the surface at the location in question, which sample represents the stationary state in the average sense. The strip is subjected to homogeneous illumination, which may meet the strip at different angles depending on the primary object, i.e. whether the color or structure is being determined. By means of a repeatedly reading semiconductor line array camera, the image of the strip is formed and converted to electric black/white or multicolor signals from which the structure or color quantities are determined in digital computer. The monitoring and analysis can be directed to both the surface of the froth layer and the surface of the froth slurry flowing down from the overflow edge.

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Method and apparatus for monitoring and analyzing the surface of floated material

General background of the invention

The desired valuable minerals are separated from the ores in the mining industry by flotation. This is effected in flotation cells of continuous flow type, in which air is conducted into vigorously mixed slurry of ground ore and water. Due to chemical preprocessing, the grains of the valuable mineral tend to adhere selectively on surfaces of air bubbles, to be lifted with these from the slurry to the froth layer above its surface. At the same time, also other mineral grains and mixed (locked) grains of a weaker tendency to float rise to this layer, and return from froth to slurry takes place as well. The froth flows continuously over the cell edge down into a launder producing the concentrate of the cell.

The final concentrate of an industrial flotation circuit consists of concentrates of individual flotation cells, which usually have been cleaned by refloating them, often in several stages. The content of the valuable mineral in the concentrate of the cell is, together with the recovery of the valuable mineral, the most important factor on which the economic value of its concentrate depends. Therefore the quality of the final concentrate and, at long intervals, also that of concentrates of the individual cells is controlled by taking samples and analyzing them in laboratory. The most important one of the instruments for immediate measurement of slurries in a flotation plant is the X-ray fluorescence analyzer which mostly analyzes metal contents of solids contained in sample streams separated from slurries. For its high price, this device however does not apply to analysis of the concentrate of a single cell, but instead of that analyzes joint samples of cell combinations or complete flotation circuits. The need for development of an instrument for on-line analysis of operation of single flotation cells or for that of material processed by them is therefore high. For this reason, an attention has recently been paid also to such measurements which relate to the flotation froth.

The appearance of the froth describes sensitively the operational state of the froth layer and even that of the whole cell, because all the material passing it and contained by it arrives to it through the slurry space of the cell. The surface of the froth is visible and the process controller traditionally inspects it by naked eye, in order to observe qualitatively its general outlook and specific features and to then

base his manual control actions on his observations and conclusions. Thus he may describe the froth e.g. one of big bubbles, porridge-type, watery, dry, stiff etc., in addition to characterization of its color.

The quantitative, instrumental evaluation of the froth has become possible, as the combination of the video camera and the computer, connected to it for the analysis of the electric image signal, has become available. Since then, several research groups have directed their work to processing of pictures taken of the flotation froth, either in order to determine structures of froths from black/white pictures (e.g. Moolman D.W. & al. in Int. J. Miner. Process. 43(1995), 193-208) or colors of froths from multi-, i.e. usually three-color pictures (e.g. Oestreich J.M. & al. in Minerals Engineering 8(1995), 31-39). Apparatuses with their software used for these aims have since then been subjected to commercialization. It is typical to said studies and apparatuses to observe a rectangular, rather large part of the industrial cell's froth surface, whose horizontal area is typically considerably larger than one square meter, and to process the sampled surface of said type as a representative sample of the cell's froth surface.

The conventional semiconductor matrix video camera device has been used in the stated studies. The U.S. Patent No 4.831.641 states, for its part, the analysis of flowing suspension in the mineral refining industry and, more particularly, the identification of solid particles in a flowing process fluid, without distinguishing the semiconductor matrix and semiconductor line array cameras from each other. It does not mention the flotation froth, and with suspensions in the stated industry one usually means two-phase solid/liquid suspensions and not the three-phase flotation froth. The illumination of the object is not presented at all in the stated patent.

An individual bubble can, if the camera and light source are located above the cell, be distinguished by means of light, which is reflected strongly back by its top area. This small, bright spot is in such a case surrounded by a darker zone. Depending on the illumination, the darkest regions may lie at the border of two bubbles, but the bottom of the valley separating the bubbles appears often also bright, because of the light it reflects, or is manifested by a stepwise change of the degree of darkness. Determination of the structural parameters of the froth, such as the mean bubble size and the form, density and size distribution of the bubbles can, further on, be based on the borderlines. The speed of the froth's movement is, for its part, determined by comparing successive pictures with each other. It is also customary to determine the brightness distribution of the imaged area and to present it in the form of a histogram. Features of the structure can also be determined by means of other

statistical methods, on the basis of the frequency of appearance of image elements of different degrees of darkness. – The deterministically and statistically determinable features stated above are examples of quantities which have been determined by image analysis and presented in the literature, and which are generally characterized by a considerably large scatter.

By means of a color video or color television camera one obtains, of the imaged field of the same type, a red, green and blue (RGB) signal, which signal set or the composite signal of standard form corresponding to it can be processed as such or transformed to other code form before processing. Determination of the color or spectrum of the froth suffers from large differences of intensity of the light reflected specularly or diffusely by the froth. Therefore e.g. too high signal elements have to be removed before processing. The color observed depends on mineral composition of the froth, but the determination of this dependence meets difficulties in practice which, in addition to the said differences of intensity, is due to the rather small differences of color of the colored metal minerals and to other, generally black/gray/white minerals present and to variation of their concentrations. Determination of both the structure and color is affected by the inhomogeneity of the quantities observable in the fields of view of the said camera instruments. This has not been taken into account in the studies reported earlier and has at least not influenced their methodologies or hardware technologies; it shall be reverted to lower down.

For the stated determinations described in the literature, one has used previously known computational algorithms or mathematical methods, which have been programmed to the form required by numerical computation in accordance with the aim of use described, or are obtainable from software libraries (See e.g. Niemi A.J. & al. in Int. J. Miner. Process. 51(1997), 51-65 and several of its reference publications). Results of the determinations can be exploited in flotation control, but because their dependence on the input quantities of flotation is generally not accurately nor unambiguously known, the statements on control and regulation have remained on the stage of draft in the literature.

Particular background of the invention

In an ideally operating flotation cell, the entering air is distributed symmetrically around its axis in the horizontal plane, an the bubbles are distributed homogeneously, still as they reach the lower interface of the froth layer. The froth leaves the cell, which typically has the form of a rectangular parallelepiped, over

one of its edges, or sometimes over its two opposite, parallel edges. Thus the liquid and solids which are carried along by the bubbles which rise to the froth layer in the rear part (correspondingly sometimes in the middle part) of the cell spend the longest time for their travel to the overflow edge and out of the cell. The amount of the stated components and of these, especially that of the others than the floatable primary mineral certainly decreases during the travel, as the bubbles break and join to each other, and as their grains either adhere to the bubbles aside or below them, displacing grains adhered more weakly to these, or flow between the bubbles down to the slurry space. That part of the material lifted in the rear part which stays in the surface layer of the froth moves, at first slowly and then, at an increasing speed, toward the overflow edge. The acceleration is caused by the new material rising everywhere to the froth layer which, despite of the selective return of the solids, gives a continuous impulse directed toward the free edge of the froth. Thus the surface is continuously reached by material lifted to the froth nearer to the overflow edge whose residence in the froth remains shorter and liberation from gangue components less. – Theoretical models of the froth layer have been derived (e.g. Moys, M.H. in Frothing in Flotation (Editor J.S. Laskowski), Gordon and Breach, UK 1989, 203-228), but they have not enabled one to make practical conclusions on the mineral concentrations of the froth surface.

As a result of the process described, the mineral composition of the froth surface changes at the transfer toward the overflow edge. This change and the continuous growth of the transfer rate in the same direction imply an inclination toward inhomogeneity, also in the structure of the froth. The inhomogeneity of the industrial flotation froth has accordingly been stated in the literature of the branch (Laplante A.R. & al. in Min. Proc. Extr. Met. Rev. 5(1989), 147-168). More lately, Niemi A.J. & al. (Int. J. Miner. Process. 51(1997), 51-65) have, in their study of apatite flotation cells, observed that the relatively light color of the froth in the rear part of the cell corresponds to a higher apatite content than that of the froth in the neighborhood of the overflow edge, the color of the latter being clearly affected by the red-brown mica present as a gangue. A video camera imaging a rather large area of the form of a rectangle has been used in the latter, experimental study in which the analysis of partial areas of the images transmitted by the camera has produced the stated result.

One may further conclude that the analysis of the information contained by a relatively large surface area as an entity, neglecting the differences of color and structure between its different parts, delivers only average results. With regard to

the concentrate produced by the cell, they have to be considered as rough approximations, especially paying attention to the fact that the part of the image area which is closest to the overflow edge is, with regard to the concentrate being formed, much more significant than the other parts or averages of the imaged area. The observation is also influenced by the inhomogeneity of illumination of the object which is the greater the larger the area of the froth surface being measured and which correspondingly distorts the image being formed on the detector.

New method and apparatus

On the basis of the stated studies and the character of the process, it is obvious that, in the surface layer of the flotation froth, the age distributions and transfer rates of the liquid phase and of the different phases of solids and, further on, the mineral compositions of the solids change, as one moves, within the surface of the froth, from the rear part (middle part) toward the overflow edge. It is also obvious that these changes have an influence on the structure and the visually observable properties of the surface layer. The age of a material element means here the time, which has been spent since its transfer to the froth layer from the slurry space.

On the other hand, there are no physical reasons to assume that changes would be present in the direction which is perpendicular to the direction of the stated movement, i.e. in that of travel from one side of the cell to the other parallelly to the overflow edge, excluding the effect which the side walls of the cell may have in their immediate neighborhood on the movement and structure of the froth. The central feature of the new method is accordingly the acquisition of representative image information of the froth layer in such a manner that the observation and the analysis of the result of observation are directed to a narrow strip of the surface, which strip is parallel to the overflow edge. The length of a strip of this kind, within which the quality of the froth is essentially even, may be equal to the breadth of the cell or less than this, e.g. in the presence of said side wall effect or for other reason, such as one related to the technology of the measuring device.

Even when the flotation process operates in a stationary state, the outcome of a momentary measurement and the property determined on the basis thereof differ from the stationary value because of the process noise. E.g. the diameter of even one, big bubble may be several percents of the length of the measured strip, and therefore the structure, brightness, color and other properties of the froth have to be determined as averaged and distributed quantities over the strip, usually by means of several, successive observations and gliding determinations. The quantities obtained

in such a manner describe the properties of the froth at each chosen location better than the quantities determined over a larger surface, which has been assumed homogeneous but is inhomogeneous in reality.

Location of the strip to be observed depends on the primary aim of the observation and analysis. With regard to the froth structure, it is best placed before the overflow edge, at a location where the speed differences caused by the overflow do not yet deform the bubbles. The data obtainable near the overflow edge and after this describes, for its part, better the final concentrate of the cell, especially with regard to the color and therefore also to the mineral concentration. On the other hand, the observation and measurement before the overflow edge can in principle, at no change of the other input quantities than the mineral concentration of the cell feed, be calibrated to indicate the mineral concentration as well.

Homogeneous illumination of the froth strip being observed can require construction of reflective surfaces and that of screens for elimination of external light, in accordance with the aim of use and the local conditions of use, but the device system for stated determinations may, in other respects, consist, for its main part, of a combination of commercially available devices. Some of such devices are AC and DC lamps of an appropriate power and emission spectrum , optical filters, semiconductor line array cameras (in special cases matrix cameras) with conventional lens optics which take black/white and color pictures at adjustable or fixed intervals, digital, primarily micro computers, devices for transfer of information between said devices and output devices for results of measurements and analyses.

The device system for carrying out the observation and analysis according to the method described may consist of e.g. the apparatus according to U.S. Patent No 4.831.641 comprising a linear photodiode array detector. In such a system, a decreased image of the aimed froth strip and of its immediate environment is formed by means of conventional, spherical optics in such a manner that the strip is imaged within the detector's area, i.e. an optics of a suitable focal length and its distance from the froth are chosen so, that the imaging takes place in the manner described. The dimensions of the detector determine, at the same time, the breadth of the froth strip being observed, and the number of its elements the resolution of the observation in the direction of the strip. The scanning rate of the detector is then chosen suitably so, that each element of the surface will be read approximately once, as the froth moves at its average speed. In addition to the detectors which consist of one semiconductor line array, also such integrated detectors are available

which comprise several, parallelly located line array detectors. In them, the signals of parallel elements are added to each other and they deliver only one, serial output signal; the line array detector stated earlier is, above and in the following, considered to comprise also such detectors. – Line scan cameras are obtainable for such uses as industrial products which sufficiently meet the requirements set to the optics, resolution of the observation and reading frequency of the detector. In addition to the one-color cameras, RGB and other color cameras are obtainable, in which the colors of the optical image signal either are separated by filters or the image signal is divided by e.g. a prism to its components, which are then guided to different semiconductor line array detectors. The optical signal range is in the following considered to cover the range of the electromagnetic, both visible and invisible radiation, such as that of the infrared and ultraviolet light to the extent to which the lens optics and semiconductor detectors are able to operate.

The electric, discrete signal corresponding to the optical image signal is read from the detector elements in the form of series of pulses, and each signal element is converted to a digital number, which is proportional to the amplitude of the signal element and therefore to the level of grayness of the image element. The reading and processing of the data and transfer of data for processing into the central unit or for storage into the memory of the computer thus proceed practically e.g. in the manner described in the stated patent. Alternatively, the information measured can also be transferred in the form of a continuous analog signal which is discretized and converted to digital data in the interface unit of the computer.

Transfer of data into the central unit of the computer and storage into its memory are programmed for implementation of such previously known methods which have been used for analysis and interpretation of information transmitted by the line array camera in the monitoring of fixed, mechanically movable pieces, like in the classification of rocks moved on a conveyor belt in the mining industry or in search and observation of surface defects of metal plates in connection with the rolling. The processing of data is programmed for implementation of the numerical methods, which are known from the analysis of a large froth surface on the basis of the image transmitted by a matrix camera, after they have been reduced to processing of one-dimensional data, or using them in their two-dimensional form, in the manner to be described in the following. Thus the grayness histogram of the froth strip is obtained by arranging the measured data according to their degree of grayness and the function describing the texture of the strip from variation of the grayness by means of e.g. the Fourier transformation, both of them as average

functions of a number of measurements and analyses. Corresponding to this, the breadths of the bubbles and the distribution of the breadth are obtained as quantities, which are determined deterministically.

A two-dimensional representation of the froth at the location of the strip is constructed, for determination of forms of the bubbles and for that of e.g. two-dimensional, statistical quantities, by joining the successive strip signals to each other. A picture of this kind represents the froth in the stationary state better than any momentary observation transmitted by the naked eye or matrix camera, or an average picture derived from such observations. The constructed, two-dimensional picture can then be processed by means of previously known methods, which have been used for the processing of froth pictures taken with the matrix camera. It can, further on, be displayed on monitor as a picture representing the strip under observation, for visual inspection and detection of properties of the froth and for that of their changes. – However, if the speed of the froth is subject to variations, it has in such a case to be determined separately and taken into account at the joining of the strip signal to the previous one. Here one may take a benefit of e.g. the fact that such bubbles which are small but have a breadth corresponding to at least several image elements are, in most mineral froths, circular as seen from above. Under such conditions one may determine, at times and using as may be needed a faster scanning frequency of the semiconductor line array detector, the time interval during which the front or rear end of each chosen bubble passes the field of view or its edges. The momentary speed of the froth in the principal direction of flow is calculated on the basis of the stated time interval and the measured breadth of the bubble, which is equal to its diameter.

Figure 1 presents a typical device system for observation of, primarily, the structure of the froth surface. The surface of the froth layer 2 above the slurry 1 is illuminated by the illuminator 3 and observed by the line array camera 4. The screen 5 checks the access of outside light to the froth strip being observed and to the camera.

Figure 2 presents a typical device system for observation of, primarily, the color of the froth. The surface of the froth layer near the overflow weir is illuminated by illuminators 7 of long form and observed by the line array color camera 8. The screen 9 and illuminators with the structures supporting them check the access of outside light to the froth strip being observed and to the camera. – The froth slurry flowing down is illuminated and observed, and the access of outside light checked by equal, essentially horizontally imaging devices 10, 11, 12. Sectional drawing B-B is so limited that the camera 11 does not appear in it.

Figure 3 is magnified drawing of a detail of illumination of the froth by illuminators according to Figure 2.

Figure 4 presents a device system for observation of the structure of the froth surface in a cylindrical flotation cell. The screen 14 checks the access of outside light to the curved froth strip being observed and to the camera.

In the embodiment according to Fig. 1, the line array camera observes a narrow froth strip, which is parallel to the overflow edge 6. At determination of the froth structure in the first place, it is illuminated from a direction which is close to that of the camera, preferably by a small-size illuminator 3. In such a case, the distinction of different bubbles can be based on reflections from their top areas. The illuminator with its reflector, possible light absorbing surfaces and choice of lamp is designed for delivery of light aimed to the froth strip being observed and being as plane as possible, and for such a distribution of light in the related plane, that it produces a homogeneous illumination of the strip along its total length. The narrow field of view and the optics of the camera 4 are guarded against outside light by a lamellar screen, the inner walls of which are painted for minimal reflectivity; less of screening is needed, if the amount of disturbing, outside light is small. Fig. 1 presents a device system described above. Because its narrowness, the apparatus covers only a small part of the froth surface and therefore does not essentially decrease the possibilities of the process operator to monitor the froth visually.

The arrangement according to Fig. 1 for illumination and imaging can be used to determination of also the color of the froth. However, for this task it is better to apply an illumination of the froth surface in a low angle or within a low range of the angle, in order to avoid large differences in the light received and reflected by the bubble surfaces of different directions and therefore e.g. the bright reflections by the tops of the bubbles. Fig. 2 presents a device system according to this, in which the illuminators 7 have been placed at the root of the observation channel, being outside this as explained by Fig. 3. They deliver homogeneously distributed light to a chosen froth strip located preferably close to the froth overflow, mainly in a direction which belongs to the symmetry plane of the reflector and is perpendicular to the illuminator of long form. The screen 9 is similar to that of Fig. 1 and the line array color camera 8 has been placed similarly to the camera of Fig. 1; thus they produce the same advantages as those stated previously. Instead of the vertical direction, the apparatus may be oriented also obliquely, e.g. so that it is perpendicular to the surface of the material, as this passes the overflow edge, or horizontally, in order to illuminate and observe a narrow strip of the froth slurry

flowing down from the overflow edge of the cell (alternative components 10, 11, 12 are hereby the same as the components 7, 8, 9 stated previously). The location of the devices for illumination and observation is essentially influenced by breakage of the bubbles at the overflow edge and after this, as the flow accelerates and hydrodynamic stresses grow rapidly. At the breakage of bubbles coming from different levels of the froth, the slurry is also mixed. Therefore the representativeness of the sample being observed as an indicator of the color and thus the concentration of the concentrate is improved, especially after the overflow edge has been passed. Whenever the color is the primary object being monitored, the description of the structure remains secondary. Therefore, and if e.g. at the same time the need of space required by the devices outside the cell is wanted to be decreased, the camera and screen can be directed obliquely to the object, especially to the surface of the froth slurry flowing down, while the orientation of the illumination with regard to the surface is not changed. This orientation of the camera and screen as an alternative to the orientation of the previously stated screen 12 and camera 11 appears from the orientation of the root of the alternative screen 13 in Fig. 3. – As far as is known, no method or apparatus for formation and real-time analysis of the optical image of the flotation product flowing down from the overflow edge has been presented earlier.

In an application related primarily to the structure of the froth, the system described is located upstream of the overflow edge area and observes an undeformed froth surface, for determination of its structure in the chosen strip. The information delivered by it represents unambiguously the stated structure, because under a steady operation of the cell the average values of all quantities are invariable, although the momentary values vary randomly. Contrary to this, the information delivered by the previously known systems using the matrix camera (typically e.g. 512 sensor elements x 512 sens. elem.) for imaging of the froth is not equally representative, since they do not take the inhomogeneity of the large, two-dimensional froth surface imaged into account. In addition to this, a narrow strip is, especially at determination of the froth color, more easily illuminated homogeneously than a large surface. Further on, the line array camera is cheaper than the matrix camera and the software needed for processing of the data produced by it is simpler than that in the case of the matrix camera. The new method does not either essentially limit a visual inspection of the froth surface.

In another application related to the color of the froth, the system described measures a color quantity which, after it has been converted to a concentration

quantity, is related to the mineral concentration of the solids. Line array color detectors and cameras incorporating them are used, whereby it is typical to their use that the color signals being obtained are in each case based on the chosen, narrow froth strip. The colors are determined on the basis of the amplitudes of the components of the color signals. With regard to the homogeneity of illumination, visual observability of the froth or slurry surface, economy of the apparatus and ease of the programming, the new color observation system is more advantageous than the corresponding system using the matrix camera, the use of which system for observation of the froth slurry at the front wall of the cell is not previously known, as stated above. – A chosen, single color signal component can additionally be used, similarly as a black/gray/white signal, for determination of the froth structure.

Also an apparatus comprising a matrix camera can be programmed to read repeatedly the same, single row of elements which is parallel to the overflow weir, whereby measured information is obtained of a narrow froth strip, in principle in the same manner as by using the line array camera system. Such a use of the matrix camera for observation and analysis of the flotation froth has, however, not been reported and, as far as is known, not applied up to the present. If used in this manner, homogeneous illumination would result, and good protection against outside sources of light and simultaneously good visual observability would, however, be reached only by using illumination and screening which are similar to those according to the new invention and which have been described in connection with the present Specification and Fig. 1. Although the use of the matrix camera in such an implementation belongs to the scope of the invention, it would be technically inconsistent to use, in absence of any benefit, the technically more complicated matrix detector for observation of a narrow, linear strip, instead of the line array camera system which is simpler and easier to use and which also belongs to the scope of the invention.

The values of the quantities corresponding to the physical properties of the froth and determined with the new method described, and the values of the quantities derived from them by computation are displayed numerically and graphically by monitors and printed by line, laser and other printers for information to the process supervisor and for application to process control by him. They can be brought also in digital and analog form to regulators and actuators controlling inputs of the flotation process, for automatic control and regulation of the process. The actuator and the input quantity of the process, which are controlled by the quantities produced in the stated manner are determined by the properties of the process being controlled.

They are chosen so that the correcting effect corresponding to the measured data or their change is accomplished and especially in the case of feedback control the measured deviation from the setpoint is eliminated. The flotation circuit or cell is, for requirements of process technology, provided with at least manual actuators of this kind and corresponding devices for automatic control are available. The stated setpoint is, for its part, that value of the measured quantity which this quantity is wanted to have at the point of measurement, under nominal conditions of operation. It may be constant, but it may also be adjusted manually or automatically, depending on the operational conditions, such as the content of the valuable mineral in the ore being processed. A new feature in automatic control of the flotation cell is implied by the new measured quantity of the control which is based on observation of the locally fixed froth strip. It describes the process more unambiguously than the earlier methods and device systems and, being brought to the devices which control the inputs of the process, produces therefore a better control result than they do.

In the preceding description of the invention, the object of its preferred application has been the conventional flotation cell in which the overflow edge is or edges are straight. Flotation cells which differ from it are also present in the industry, and similarly e.g. cells provided with scrapers of froth, but making the logically required changes one may apply the new method also to them. Application to a cylindrical flotation cell whose overflow edge is a horizontal circle or part of a circle is presented in the following, as an example of such a different type of embodiment of the invention.

In the cylindrical flotation cell presented in Fig. 4, the strip being observed is, analogously with the preceding text, a curved area of the froth surface which is limited by two circular arcs which have a common center point with the cell. The stated area is thus everywhere parallel to, and of the same form as the overflow edge. Its longer radius is normally the same as, or shorter than the radius of the overflow edge. The chosen length of the strip which has been considered representative determines its part of the full circle or the corresponding central angle, and the side wall effect mentioned in connection with the embodiment described earlier is now absent.

Especially at determination of the froth structure, the illumination and imaging of the strip can be directed to take place between such conic surfaces which pass the strip along its edges, whereby the length of the strip determines the needed breadth of the part of conic surface. This part tapers linearly up to the top of the corresponding cone, which in the case of a straight cone is located above the cell, on

the central axis. However, it is often more advantageous to locate the tops outside the central axis, above the axis of the sector limited by the strip, whereby the corresponding surfaces are parts of oblique, conic surfaces. The camera may be located e.g. vertically above that point of the sector axis which is the median point of the total strip surface in the axial direction. The outer surface may thereby practically be, instead of the a part of oblique, conic surface referred to above, a part of that vertical, cylindrical surface which is determined by the outer edge of the strip, and only the inner surface a part of an oblique, conic surface. – The stated conic and cylindrical surfaces 14 and the side walls connecting them to each other check the outside light from disturbing the froth observation, by checking its access to the area being imaged and to the camera.

The small-size light source and camera are located between the tops of the cones stated or meant above, or close to this place. The curved froth strip is imaged camera-optically e.g. on a narrow sensor of the form of a semicircular arc consisting of semiconductor elements; such sensors have been produced for special uses. The distance and focal length of the camera are fitted in such a manner, that the image of the desired strip falls for its whole length on said sensor or on such part of the sensor which corresponds to the length of the strip. The discrete, electrical image signal is thereafter read and interpreted in the manner presented in a previous place, for the case of the linear array detector.

If the overflow edge is not straight, it may prove difficult to find a sensor of suitable curvature and number of elements. For this reason and also for simplification of focussing of the image, it may prove beneficial to use the conventional semiconductor matrix sensor and camera in such a case, although its use in the case of the flotation cell with straight edges, for observation of the straight froth strip, was previously shown technically inconsistent as compared with the use of the line array camera. Using now the matrix camera for observation of the froth surface in e.g. a cylindrical cell, the narrow strip of the same direction and form as the overflow edge is corresponded by a sensor element set of the same form on the matrix sensor, which elements form a connected chain. The distinction and separation of the corresponding, electrical set of elements from the digital image signal being obtained are logically managed by a professional who is familiar with image processing.

Correspondingly, the determination of the froth color proceeds in the case of a cylindrical cell using most appropriately the conventional matrix color sensor and camera in the same manner as that presented above about the use of the black/white

camera, taking with regard to the use of the electrical color signals into account those special features which were presented earlier on use of the line array color camera for observation of the froth color in a cell with straight edges. Also the homogeneous illumination in a low angle needed here is accomplished analogously to the illumination of the straight froth strip. Since however the accomplishment of an illumination following the curved edge of the conic or cylindrical surface may hereby prove difficult, it can be produced approximately, by dividing it to several straight illuminators along the edge. Correspondingly, the conic and cylindrical surfaces can be divided to the same number of plane surface segments with straight edges, removing the opposite surfaces farther from each other in such a manner that a sufficient homogeneity remains and no part of the object strip falls in shade.

After the image of the curved froth strip has been formed and transferred to a computer in the manner described in the preceding paragraphs, it can be subjected to the analysis procedures which were presented earlier, in connection with the flotation cell of parallelepiped form. E.g. a two-dimensional picture of the froth at the location of the strip is formed in a manner which corresponds to that presented earlier. At the same time, one may straighten each one of the strips to be joined to a linear form without changing the amplitude readings of its elements. The picture born by such means is formed in a rectangular coordinate system which is convenient considering the use of most, numerical analysis methods.

In the case of the froth slurry flowing down along the cylindrical surface of the cell, both the illumination and imaging are accomplished with units according to Fig. 2 which are constructed to be sufficiently narrow and installed next to each other, at the same height and at the same distance from the cylindrical surface each, so that a sufficiently homogeneous illumination and geometrically sufficiently correct image is reached. The signals delivered by the line array color sensors are then combined in the common computer of the units, in order to produce color information which represents a sufficiently wide froth slurry flow. Under good conditions, when the froth slurry flowing down is homogeneous in the horizontal direction over the cylindrical surface, even a single illumination and observation unit may be sufficient for delivery of representative color information.

In the same manner as in the embodiment presented above, the new invention is considered to cover the applications of the presented method to other flotation devices which differ in the details of their structure and to which its application, on the basis of the presentation above, is obvious to a professional skilled in the art. Similarly the structures and instruments for production of the wanted illumination

and observation are to be understood as examples which cover also such devices which for different objects of use are natural alternatives to a professional. – The economy of the apparatus according to the invention and its technical simplicity make its use, taking the expected improvement of quality of the concentrate into account, advantageous in many, even in all cells of a larger flotation system and a complete flotation plant. An additional, technical and economic benefit is thereby produced by centralization of the processing of image information so, that the signals transmitted by several cameras are processed by common computer or computers, and the output of the data determined is concentrated as needed to common devices for presentation and to devices controlling the larger flotation system.

Claims

1. Method for monitoring and analyzing the surface of floated material, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to physical and statistical properties of said material and surface, characterized in that said image is at the optoelectrical conversion limited to a narrow rectangle and divided to a row of image elements, that the elements of the detected, eletrical signals correspond individually to said image elements and that, corresponding optically to said, to a narrow rectangle limited image, the area of the same form on said surface is homogeneously illuminated and parallel to the overflow edge of a flotation cell.

2. Apparatus for carrying out the method according to Claim 1, comprising, in combination,

- at least one light source (3) and optical components for illumination of the surface of floated material, and a screen (5) for checking the access of outside light,

- a camera (4) for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to physical and statistical properties of froth, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said camera (4) is a semiconductor line array camera comprising a semiconductor line array detector which camera produces said electrical signals on the basis of the image of a narrow strip of the surface of the floated material said strip being parallel to the overflow edge (6), and that said at least one light source (3), optical components and screen (5) produce homogeneous illumination to said strip from a direction which is close to that of said camera.

3. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to sets of electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to the color and other physical and statistical properties of said flotation froth and surface,

characterized in that said image is at the optoelectrical detection limited to a narrow rectangle and divided to sets of image elements arranged in rows and representing different color components, whereby the number of said rows is at most same as the number of said color components, that the detected elements of the eletrical signal sets correspond individually to said image elements, and the detected, electrical signal sets to said sets of image elements representing different color components and that, corresponding optically to said image limited to a narrow rectangle, the area of the same form on said surface is homogeneously illuminated and parallel to the overflow edge of the flotation cell.

4. Method for monitoring and analyzing the surface of the froth slurry flowing down from the overflow edge of flotation cell, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to sets of electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to color and other physical and statistical properties of said froth slurry and surface, characterized in that said image is at the optoelectrical detection limited to a narrow rectangle and divided to sets of image elements arranged in rows and representing different color components, whereby the number of said rows is at most same as the number of said color components, that the detected elements of the eletrical signal sets correspond individually to said image elements, and the detected, electrical signal sets to said sets of image elements representing different color components and that, corresponding optically to said image limited to a narrow rectangle, the area of the same form on said surface is homogeneously illuminated and parallel to the overflow edge of the flotation cell.

5. Apparatus for carrying out the method according to Claim 3 or 4, comprising, in combination,

- at least one light source (7, 10) and optical components for illumination of the surface of floated material (1, 2), and a screen (9, 12) for checking the access of outside light,

- a camera (8, 11) for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity, and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to color and other physical and statistical properties of

floated material, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said camera (8, 11) is a color video camera provided with optoelectrical semiconductor line array detectors which camera produces said electrical signals on the basis of the image of a narrow strip of the surface of the floated material said strip being parallel to the overflow edge (6), and that said at least one light source (7, 10), optical components and screen (9, 12) produce to said strip homogeneous illumination which meets said strip in a low angle.

6. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to physical and statistical properties of said flotation froth and surface, characterized in that, from said electrical signals, those are separated and processed digitally which are induced by a narrow image which is bounded to the form of the overflow edge and divided to a chain of image elements, that the elements of the electrical signals being processed digitally correspond individually to said image elements and that, corresponding optically to said narrow image which is bounded to the form of the overflow edge, the area of the same form on said surface is homogeneously illuminated and everywhere at an equal distance from the overflow edge of the flotation cell.

7. Apparatus for carrying out the method according to Claim 6, comprising, in combination,

- at least one light source and optical components for illumination of the surface of flotation froth, and a screen (14) for checking the access of outside light,

- a semiconductor matrix video camera for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to physical and statistical properties of froth, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said digital computer has been programmed to separate and process digitally the electrical signals which are induced by a narrow area bounded to the form of the overflow edge in the image which is formed by said camera of a locally fixed, narrow area of the surface of the flotation froth which area has the form of the overflow edge, and that said at least one light source, optical components and screen (14) produce homogeneous illumination to said area of said surface from a direction which is close to that of said camera.

8. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to the color and other physical and statistical properties of said flotation froth and surface, characterized in that, from said electrical signals, those are separated and processed digitally which are induced by a narrow image area which is bounded to the form of the overflow edge, which image area is at the optoelectrical conversion divided to chains of image elements which chains have an equal form and represent different color components, whereby the number of said chains is at most same as the number of said color components, that the elements of the electrical signals being processed digitally correspond individually to said image elements and that, corresponding optically to said narrow image which is bounded to the form of the overflow edge, the area of the same form on said surface is homogeneously illuminated and everywhere at an equal distance from the overflow edge of the flotation cell.

9. Apparatus for carrying out the method according to Claim 8, comprising, in combination,

- at least one light source and optical components for illumination of the surface of flotation froth, and a screen (14) for checking the access of outside light,

- a semiconductor matrix color video camera for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to the color and other physical and statistical properties of the flotation froth and surface, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said digital computer has been programmed to separate and process digitally the electrical signals which are induced by a narrow area bounded to the form of the overflow edge in the image which is formed by said camera of a locally fixed, narrow area of the surface of the flotation froth which area has the form of the overflow edge, and that said at least one light source, optical components and screen (14) produce to said area of said surface homogeneous illumination which meets said area of said surface in a low angle.

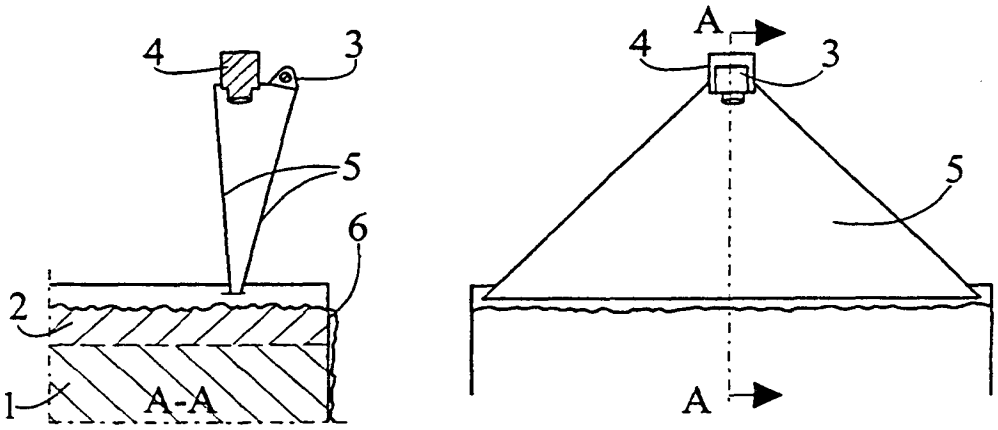

Fig. 1

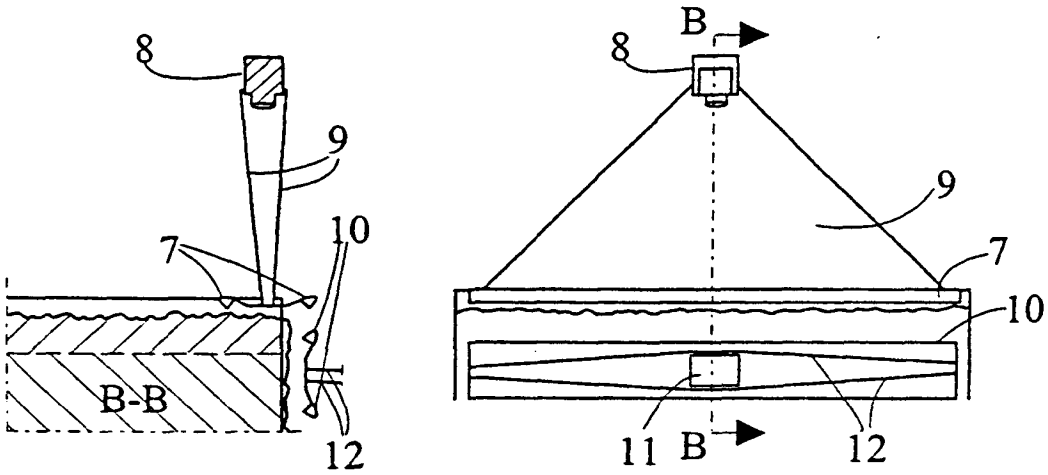

Fig. 2

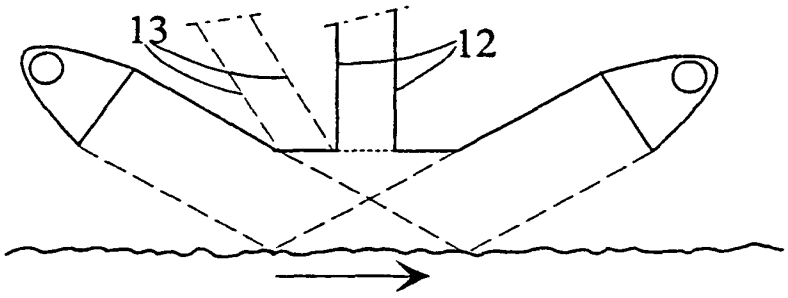

Fig. 3

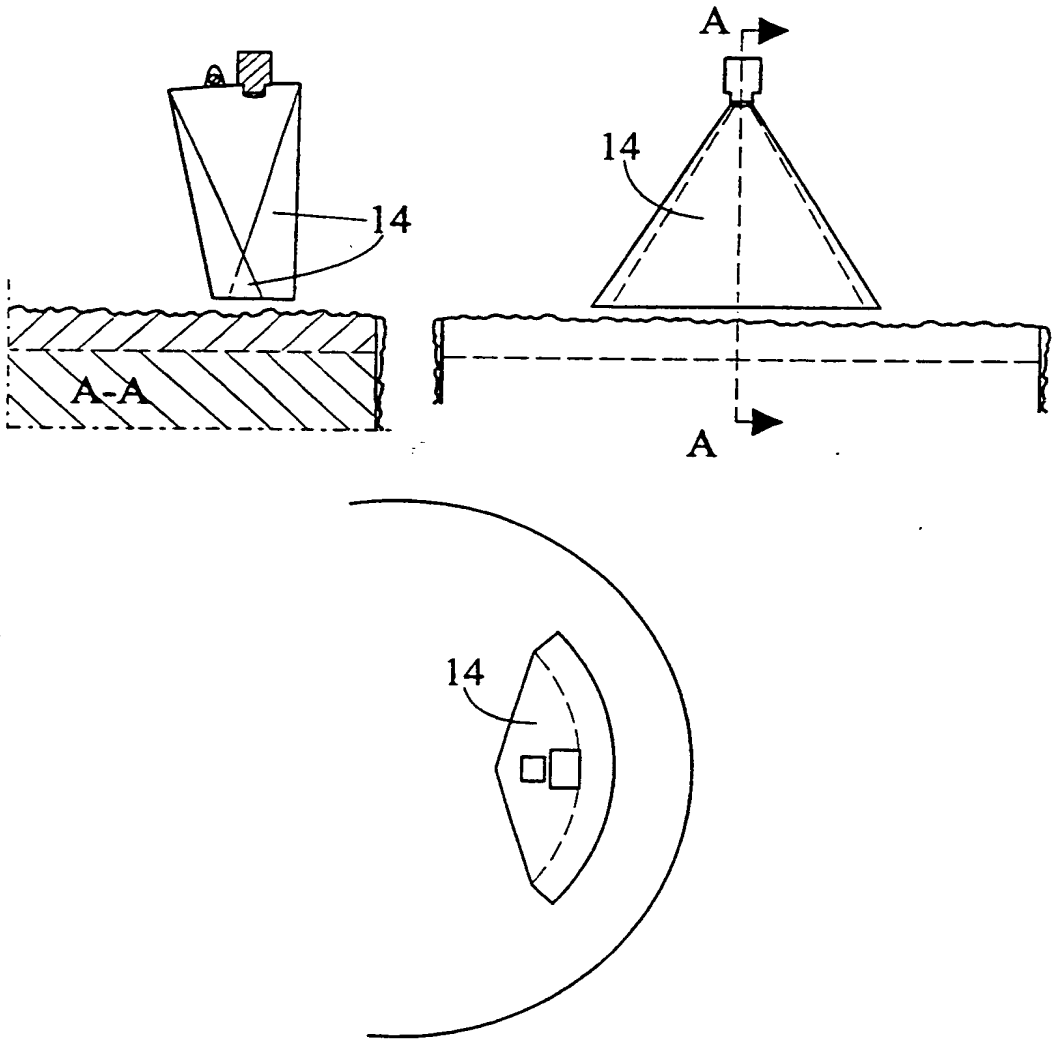

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00400

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G01N 21/85, B03B 13/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G01N, B03B, B03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CIPRIANO,A.ET AL."EXPERT SYSTEM FOR SUPERVISION OF MINERAL FLOTATION CELLS USING ARTIFICAL VISION" in:Industrial Electronics,1997,ISIE'1997., Proceedings of the IEEE International Symposium on p.149-153 vol.1 7-11 July 1997. see fig.1;p.151, col.1,li.10 - li. 31. --	1-9
X	GUARINI,M.ET AL"A SENSOR FOR ASSESSING THE QUALITY OF MINERAL FLOTATION PROCESS".In:Industrial Electronics,1994.Symposium Proceedings,ISIE'94., 1994 IEEE INTERNATIONAL SYMPOSIUM on p:386 - 391 25-27 MAY 1994. See p.386,col.2, li. 17 -p.387, col.1, li.23 --	1-9

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 Sept 2000	08 -09- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Gunnel Wästerlid/itw Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00400

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2084723 A (KLOOCKNER-HUMBOLDTDEUTZ AKTIENGESELLSCHAFT), 5 October 1981 (05.10.81), page 3, line 102 - line 124, figure 2 --	1-9
A	US 5038258 A (K-P.KOCH ET AL), 6 August 1991 (06.08.91), column 2, line 39 - line 64; column 10, line 66 - column 12, line 15, figure 7 --	1-9
A	US 5024334 A (M.MISRA ET AL), 18 June 1991 (18.06.91), column 9, line 44 - line 64, abstract --	1-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

08/05/00

International application No.
PCT/FI 00/00400

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2084723 A	05/10/81	DE 3037594 A	19/05/82
		ZA 8106838 A	29/09/82
US 5038258 A	06/08/91	DE 3906555 A	06/07/89
		DE 8915535 U	25/10/90
		DE 59009541 D	00/00/00
		EP 0385262 A,B	05/09/90
		JP 2272412 A	07/11/90
		JP 2650215 B	03/09/97
US 5024334 A	18/06/91	NONE	

I. Basis of th pinion

1. With regard to the **elements** of the international application (Replacement *sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed"*):

Description, pages:

1-15 as originally filed

Claims, No.:

1-11 as received on 04/12/2000 with letter of 07/11/2000

Drawings, sheets:

1/2,2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been and will not be examined in respect of:

   ☒ the entire international application,

   ☐ claims Nos. ,

because:

   ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

   ☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 1-11 are so unclear that no meaningful opinion could be formed (*specify*):
   see separate sheet

   ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

   ☐ no international search report has been established for the said claims Nos. .

2. A written opinion cannot be drawn due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the standard.

   ☐ the computer readable form has not been furnished or does not comply with the standard.

The present set of claims contains **eleven** independent claims and no dependent claim. Although these claims have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each other only with regard to the definition of the subject-matter for which protection is sought and/or in respect of the terminology used for the features of that subject-matter. The aforementioned claims therefore lack conciseness. Moreover, lack of clarity of the claims as a whole arises (Art. 6 PCT), since the plurality of independent claims makes it impossible to determine the matter for which protection is sought, and places an undue burden on others seeking to establish the extent of the protection.

Accordingly, examination of the novelty and inventive step of the subject-matter of the claims is postponed, until an amended set of claims is filed defining the relevant subject-matter in terms of a single independent claim in each category followed by dependent claims covering features which are merely optional (Rule 6.4 PCT).

When drafting the new set of claims, the applicant should take into consideration the teachings of the documents of the search report, especially of the X documents.

Berggren
PATENTTITOIMISTO • PATENT & TRADEMARK ATTORNEYS

7 November 2000

By facsimile – C nfirmation by mail
Patent- och registreringsverket
Valhallavägen 136
P.O. Box 5055
S-102 42 Stockholm
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Our ref: 49990/LN/JAS

INTERNATIONAL PATENT APPLICATION PCT/FI00/00400
APPLICANT: NIEMI, ANTTI JOHANNES
AMENDMENTS UNDER ARTICLE 19

Dear Sirs,

Enclosed please find a new set of claims replacing the claims previously on file.

Claim 4 has been amended so as to state the new feature that the "froth slurry is the froth slurry flowing down from the overflow edge..." in the characterizing part of the claim.

Furthermore, new claims 10 and 11 have been added. Both new claims refer to said feature of analyzing particularly the froth slurry overflowing the edge of the cell.

Claims 1-3 and 5-9 remain unamended.

Yours faithfully,
BERGGREN OY AB

Leif Nordin
Patent Agent

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VAT FI0107002?
Kotipaikka Helsinki

Claims

1. Method for monitoring and analyzing the surface of floated material, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to physical and statistical properties of said material and surface, **characterized** in that said image is at the optoelectrical conversion limited to a narrow rectangle and divided to a row of image elements, that the elements of the detected, eletrical signals correspond individually to said image elements and that, corresponding optically to said, to a narrow rectangle limited image, the area of the same form on said surface is homogeneously illuminated and parallel to the overflow edge of a flotation cell.

2. Apparatus for carrying out the method according to Claim 1, comprising, in combination,

- at least one light source (3) and optical components for illumination of the surface of floated material, and a screen (5) for checking the access of outside light,

- a camera (4) for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to physical and statistical properties of froth, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said camera (4) is a semiconductor line array camera comprising a semiconductor line array detector which camera produces said electrical signals on the basis of the image of a narrow strip of the surface of the floated material said strip being parallel to the overflow edge (6), and that said at least one light source (3), optical components and screen (5) produce homogeneous illumination to said strip from a direction which is close to that of said camera.

3. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to sets of electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to the color and other physical and statistical properties of said flotation froth and surface,

characterized in that said image is at the optoelectrical detection limited to a narrow rectangle and divided to sets of image elements arranged in rows and representing different color components, whereby the number of said rows is at most same as the number of said color components, that the detected elements of the eletrical signal sets correspond individually to said image elements, and the detected, electrical signal sets to said sets of image elements representing different color components and that, corresponding optically to said image limited to a narrow rectangle, the area of the same form on said surface is homogeneously illuminated and parallel to the overflow edge of the flotation cell.

4. Method for monitoring and analyzing the surface of a froth slurry, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to sets of electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to color and other physical and statistical properties of said froth slurry and surface, **characterized** in that said froth slurry is the froth slurry flowing down from the overflow edge of flotation cell, that said image is at the optoelectrical detection limited to a narrow rectangle and divided to sets of image elements arranged in rows and representing different color components, whereby the number of said rows is at most same as the number of said color components, that the detected elements of the eletrical signal sets correspond individually to said image elements, and the detected, electrical signal sets to said sets of image elements representing different color components and that, corresponding optically to said image limited to a narrow rectangle, a narrow area of rectangular form on said surface is homogeneously illuminated and parallel to the overflow edge of the flotation cell.

5. Apparatus for carrying out the method according to Claim 3 or 4, comprising, in combination,

- at least one light source (7, 10) and optical components for illumination of the surface of floated material (1, 2), and a screen (9, 12) for checking the access of outside light,

- a camera (8, 11) for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity, and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to color and other physical and statistical properties of

floated material, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said camera (8, 11) is a color video camera provided with optoelectrical semiconductor line array detectors which camera produces said electrical signals on the basis of the image of a narrow strip of the surface of the floated material said strip being parallel to the overflow edge (6), and that said at least one light source (7, 10), optical components and screen (9, 12) produce to said strip homogeneous illumination which meets said strip in a low angle.

6. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to physical and statistical properties of said flotation froth and surface, **characterized** in that, from said electrical signals, those are separated and processed digitally which are induced by a narrow image which is bounded to the form of the overflow edge and divided to a chain of image elements, that the elements of the electrical signals being processed digitally correspond individually to said image elements and that, corresponding optically to said narrow image which is bounded to the form of the overflow edge, the area of the same form on said surface is homogeneously illuminated and everywhere at an equal distance from the overflow edge of the flotation cell.

7. Apparatus for carrying out the method according to Claim 6, comprising, in combination,

- at least one light source and optical components for illumination of the surface of flotation froth, and a screen (14) for checking the access of outside light,

- a semiconductor matrix video camera for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to physical and statistical properties of froth, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said digital computer has been programmed to separate and process digitally the electrical signals which are induced by a narrow area bounded to the form of the overflow edge in the image which is formed by said camera of a locally fixed, narrow area of the surface of the flotation froth which area has the form of the overflow edge, and that said at least one light source, optical components and screen (14) produce homogeneous illumination to said area of said surface from a direction which is close to that of said camera.

8. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to the color and other physical and statistical properties of said flotation froth and surface, **characterized** in that, from said electrical signals, those are separated and processed digitally which are induced by a narrow image area which is bounded to the form of the overflow edge, which image area is at the optoelectrical conversion divided to chains of image elements which chains have an equal form and represent different color components, whereby the number of said chains is at most same as the number of said color components, that the elements of the electrical signals being processed digitally correspond individually to said image elements and that, corresponding optically to said narrow image which is bounded to the form of the overflow edge, the area of the same form on said surface is homogeneously illuminated and everywhere at an equal distance from the overflow edge of the flotation cell.

9. Apparatus for carrying out the method according to Claim 8, comprising, in combination,

- at least one light source and optical components for illumination of the surface of flotation froth, and a screen (14) for checking the access of outside light,

- a semiconductor matrix color video camera for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to the color and other physical and statistical properties of the flotation froth and surface, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said digital computer has been programmed to separate and process digitally the electrical signals which are induced by a narrow area bounded to the form of the overflow edge in the image which is formed by said camera of a locally fixed, narrow area of the surface of the flotation froth which area has the form of the overflow edge, and that said at least one light source, optical components and screen (14) produce to said area of said surface homogeneous illumination which meets said area of said surface in a low angle.

10. Method for monitoring and analyzing the surface of a froth slurry, in which an optical image of said surface is formed continuously and converted repeatedly, opto-electrically to sets of electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to color and other physical and statistical properties of said froth slurry and surface, **characterized** in that said froth slurry is the froth slurry flowing down from the overflow edge of flotation cell, that said image is at the optoelectrical detection limited to a rectangle and divided to sets of image elements arranged in rows and representing different color components, that the detected elements of the eletrical signal sets correspond individually to said image elements, and the detected, electrical signal sets to said sets of image elements representing different color components and that the area, which on said surface corresponds optically to said image limited to a rectangle, is illuminated in a low angle and parallel to the overflow edge of the flotation cell.

11. Apparatus for carrying out the method according to Claim 10, comprising, in combination,

- at least one light source and optical components for illumination of the surface of froth slurry, and a screen for checking the access of outside light,

- a camera for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity, and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to color and other physical and statistical properties of froth slurry, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said camera is a color video camera provided with at least one optoelectrical semiconductor matrix detector which camera produces said electrical signals on the basis of the image of a rectangular area of the surface of the froth

slurry flowing down from the overflow edge of flotation cell, a side of said rectangular area being parallel to the overflow edge, and that said at least one light source, optical components and screen produce to said rectangular area an illumination which meets it in a low angle.

Claims

1. Method for monitoring and analyzing the surface of floated material, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to physical and statistical properties of said material and surface, **characterized** in that said image is at the optoelectrical conversion limited to a narrow rectangle and divided to a row of image elements, that the elements of the detected, eletrical signals correspond individually to said image elements and that, corresponding optically to said, to a narrow rectangle limited image, the area of the same form on said surface is homogeneously illuminated and parallel to the overflow edge of a flotation cell.

2. Apparatus for carrying out the method according to Claim 1, comprising, in combination,

- at least one light source (3) and optical components for illumination of the surface of floated material, and a screen (5) for checking the access of outside light,

- a camera (4) for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to physical and statistical properties of froth, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said camera (4) is a semiconductor line array camera comprising a semiconductor line array detector which camera produces said electrical signals on the basis of the image of a narrow strip of the surface of the floated material said strip being parallel to the overflow edge (6), and that said at least one light source (3), optical components and screen (5) produce homogeneous illumination to said strip from a direction which is close to that of said camera.

3. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to sets of electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to the color and other physical and statistical properties of said flotation froth and surface,

characterized in that said image is at the optoelectrical detection limited to a narrow rectangle and divided to sets of image elements arranged in rows and representing different color components, whereby the number of said rows is at most same as the number of said color components, that the detected elements of the eletrical signal sets correspond individually to said image elements, and the detected, electrical signal sets to said sets of image elements representing different color components and that, corresponding optically to said image limited to a narrow rectangle, the area of the same form on said surface is homogeneously illuminated and parallel to the overflow edge of the flotation cell.

4. Method for monitoring and analyzing the surface of the froth slurry flowing down from the overflow edge of flotation cell, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to sets of electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to color and other physical and statistical properties of said froth slurry and surface, **characterized** in that said image is at the optoelectrical detection limited to a narrow rectangle and divided to sets of image elements arranged in rows and representing different color components, whereby the number of said rows is at most same as the number of said color components, that the detected elements of the eletrical signal sets correspond individually to said image elements, and the detected, electrical signal sets to said sets of image elements representing different color components and that, corresponding optically to said image limited to a narrow rectangle, the area of the same form on said surface is homogeneously illuminated and parallel to the overflow edge of the flotation cell.

5. Apparatus for carrying out the method according to Claim 3 or 4, comprising, in combination,

- at least one light source (7, 10) and optical components for illumination of the surface of floated material (1, 2), and a screen (9, 12) for checking the access of outside light,

- a camera (8, 11) for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity, and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to color and other physical and statistical properties of

floated material, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said camera (8, 11) is a color video camera provided with optoelectrical semiconductor line array detectors which camera produces said electrical signals on the basis of the image of a narrow strip of the surface of the floated material said strip being parallel to the overflow edge (6), and that said at least one light source (7, 10), optical components and screen (9, 12) produce to said strip homogeneous illumination which meets said strip in a low angle.

6. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to physical and statistical properties of said flotation froth and surface, **characterized** in that, from said electrical signals, those are separated and processed digitally which are induced by a narrow image which is bounded to the form of the overflow edge and divided to a chain of image elements, that the elements of the electrical signals being processed digitally correspond individually to said image elements and that, corresponding optically to said narrow image which is bounded to the form of the overflow edge, the area of the same form on said surface is homogeneously illuminated and everywhere at an equal distance from the overflow edge of the flotation cell.

7. Apparatus for carrying out the method according to Claim 6, comprising, in combination,

- at least one light source and optical components for illumination of the surface of flotation froth, and a screen (14) for checking the access of outside light,

- a semiconductor matrix video camera for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to physical and statistical properties of froth, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said digital computer has been programmed to separate and process digitally the electrical signals which are induced by a narrow area bounded to the form of the overflow edge in the image which is formed by said camera of a locally fixed, narrow area of the surface of the flotation froth which area has the form of the overflow edge, and that said at least one light source, optical components and screen (14) produce homogeneous illumination to said area of said surface from a direction which is close to that of said camera.

8. Method for monitoring and analyzing the surface of flotation froth, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to the color and other physical and statistical properties of said flotation froth and surface, **characterized** in that, from said electrical signals, those are separated and processed digitally which are induced by a narrow image area which is bounded to the form of the overflow edge, which image area is at the optoelectrical conversion divided to chains of image elements which chains have an equal form and represent different color components, whereby the number of said chains is at most same as the number of said color components, that the elements of the electrical signals being processed digitally correspond individually to said image elements and that, corresponding optically to said narrow image which is bounded to the form of the overflow edge, the area of the same form on said surface is homogeneously illuminated and everywhere at an equal distance from the overflow edge of the flotation cell.

9. Apparatus for carrying out the method according to Claim 8, comprising, in combination,

- at least one light source and optical components for illumination of the surface of flotation froth, and a screen (14) for checking the access of outside light,

- a semiconductor matrix color video camera for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and

- a digital computer for receiving and processing said signals, and for determining quantities corresponding to the color and other physical and statistical properties of the flotation froth and surface, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that said digital computer has been programmed to separate and process digitally the electrical signals which are induced by a narrow area bounded to the form of the overflow edge in the image which is formed by said camera of a locally fixed, narrow area of the surface of the flotation froth which area has the form of the overflow edge, and that said at least one light source, optical components and screen (14) produce to said area of said surface homogeneous illumination which meets said area of said surface in a low angle.

09/980515

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

14

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
49990		

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/FI00/00400	05/05/2000	05/05/1999

International Patent Classification (IPC) or national classification and IPC
G01N21/85

Applicant
NIEMI, Antti

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 3 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
04/12/2000	07.08.2001

Name and mailing address of the international preliminary examining authority:

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/FI00/00400

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-15 as originally filed

Claims, No.:

1-12 with telefax of 20/06/2001

Drawings, sheets:

1/2,2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
   see separate sheet

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

   ☐ the entire international application.

   ☒ claims Nos. 1-6.

because:

   ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

   ☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 1-6 are so unclear that no meaningful opinion could be formed (*specify*):
   see separate sheet

   ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

   ☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the standard.

   ☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

   Novelty (N) Yes: Claims 7-12

	No:	Claims	
Inventive step (IS)	Yes:	Claims	7-12
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	7-12
	No:	Claims	

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Concerning item I:

For the following reasons, new independent Claim 1 is considered to include subject-matter which goes beyond the content of the application as originally filed:
a) All the original method claims contained a feature relative to the obtention of a narrow image either parallel or bounded to the overflow edge of the flotation cell. This feature is not present in new Claim 1, although there is no support in the description for such an amendment (see for example on page 5, lines 22-25, of the description, where this feature is called the "central feature of the new method").
b) The original method claims further included a step of homogeneously illuminating the narrow area to be monitored. This step has been omitted in drafting new Claim 1, although, according to the description, this step appears to be essential for carrying out the present invention.
c) The term "that said image is ... different color components." in the characterizing part tries to encompass all the embodiments defined in the original method claims. However, this generalization of the invention makes that embodiments that were not disclosed originally are now present in Claim 1. For example, in original method claims 3 and 4 which contained a step of dividing the image to sets of image elements representing different colors components said image elements were arranged in rows. The wording of present Claim 1 is very much broader now since it suggests that said image elements could take any shape, although this would not be, for the skilled person, directly and unambiguously derivable from the original disclosure, especially in view of the lack of clarity of the method claims as filed.

Concerning item III:

See item VIII.

Concerning item V:

A) Claims 7-11:

The subject-matter of new independent apparatus Claim 7, as well as that of dependent Claims 8 to 11, is considered to be novel and inventive with respect to the available prior art, since none of the documents of the search report discloses or suggests an

apparatus for monitoring the surface of floated material having one light source, optical components and a screen (for checking the access of outside light) producing together homogeneous illumination of the monitored area. With the apparatus disclosed in document entitled "Expert system for supervision ..." no homogeneous illumination can be achieved since a single light source is used for illuminating a very large area (see Fig. 1 of that document). Document entitled "A sensor for assessing the quality of the mineral flotation process" is silent about the illumination of the material. As to document GB-A-2084723, it is not relevant either, because a laser is employed for illuminating the material.

B) Claim 12:

The apparatus of Claim 12 of the application comprises a screen for checking the access of outside light to the monitored surface. This feature is neither revealed in, nor suggested by, the available prior art, since there is no need with the known apparatuses for monitoring floated material to prevent ambient light from impinging onto said material.

Concerning item VIII:

The term "divided to sets of image elements .. representing different color components." in the characterizing part of new Claim 1 is totally unclear, contrary to the requirements of Art. 6 PCT. First, the object to be achieved by these steps is not understood. Secondly, it is not clear: a) whether the "image elements" are fixed parts of the image to which are always assigned the same color or whether these image elements, i.e. their size and/or shape, vary with the viewed material, i.e. an image element would be a group of pixels of the recorded image having at a given time the same color; b) what "the sets of elements of the detected, electrical signals" are and how they are produced.

Since method Claims 2 to 6 are dependent upon Claim 1, these claims are considered to lack clarity too.

Claims

1. Method for monitoring and analyzing the surface of floated material, in which an optical image of said surface is formed continuously and converted repeatedly, optoelectrically to electrical signals which are read, transferred and processed digitally for determination and output of quantities corresponding to physical and statistical properties of said material and surface, **characterized** in that said floated material is the froth slurry flowing down from the overflow edge of flotation cell, that said image is at the optoelectrical conversion limited to a rectangle and divided to sets of image elements representing different color components, and that sets of elements of the detected, electrical signals are produced corresponding to said sets of image elements representing different color components.

2. Method according to claim 1 in which said floated material is the flotation froth upon a flotation cell, **characterized** in that said image is at the optoelectrical conversion limited to a narrow strip with sides of the same form as the overflow edge is divided to a chain of image elements, and that the elements of the detected, electrical signals correspond individually to said image elements and that, corresponding optically to said, to a narrow strip limited image, a strip of the same form on said surface is homogeneously illuminated and everywhere at an equal distance from the overflow edge of a flotation cell.

3. Method according to claim 2, **characterized** in that said image limited to a narrow strip is divided to sets of image elements arranged in chains of an equal form and representing different color components, whereby the number of said chains is at most same as the number of said color components, and that sets of elements of the electrical signals are produced corresponding to said sets of image elements representing different color components.

4. Method according to claim 2 wherein said flotation cell has a straight overflow edge, **characterized** in that said image is limited to a narrow rectangle consisting of a row of image elements.

5. Method according to claim 3 wherein said flotation cell has a straight overflow edge, **characterized** in that the sets of image elements are arranged in rows and that the number of said rows is at most same as the number of said color components.

6. Method according to claim 1, **characterized** in that said image is limited to a narrow rectangle and divided to rows of image elements representing different color components, whereby the number of said rows is at most same as the number of said color components.

7. Apparatus for monitoring and analyzing the surface of floated material, comprising:

- at least one light source (3, 7, 10) and optical components for illumination of the surface of floated material, and a screen (5,9,12,14) for checking the access of outside light,
- a camera (4, 8, 11) for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity and
- a digital computer for receiving and processing said signals, and for determining quantities corresponding to physical and statistical properties of froth, with its interfaces for delivering the values of said quantities to central supervision and process control devices,

characterized in that the electrical signals produced by said camera and processed by said computer are based on the optical image of a narrow strip of said surface of floated material, the sides of said strip being parallel to the overflow edge (6) of the flotation cell, and that said at least one light source, optical components and screen produce homogeneous illumination to said strip.

8. Apparatus as defined in claim 7 , **characterized** in that said camera is a semiconductor line array camera comprising an optoelectrical semiconductor line array detector and that said homogeneous illumination is provided from a direction which is close to that of said camera.

9. Apparatus as defined in claim 7, **characterized** in that said camera is a color video camera provided with optoelectrical semiconductor line array detectors and that said homogeneous illumination meets said strip in a low angle.

10. Apparatus as defined in claim 7, wherein said floated material is the flotation froth upon a flotation cell and said camera is a semiconductor matrix video camera,

characterized in that said digital computer is programmed to separate and process digitally the electrical signals which are induced by a narrow image strip with sides of the same form as the overflow edge of the flotation cell, said image strip corresponding optically to a locally fixed, narrow froth strip of the same form on the surface of the flotation froth, and that said homogeneous illumination to said froth strip is provided from a direction which is close to that of said camera.

11. Apparatus as defined in claim 7, wherein said floated material is the flotation froth upon a flotation cell and said camera is a semiconductor matrix color video camera, **characterized** in that said digital computer is programmed to separate and process digitally the electrical signals which are induced by a narrow image strip with sides of the same form as the overflow edge of the flotation cell, said image strip corresponding optically to a locally fixed, narrow froth strip of the same form on the surface of the flotation froth, and that said homogeneous illumination meets said froth strip in a low angle.

12. Apparatus for monitoring and analyzing the surface of floated material, **characterized** in that the apparatus comprises:

- at least one light source and optical components for illumination, in a low angle, of the surface of froth slurry flowing down from the overflow edge of a flotation cell, and a screen for checking the access of outside light to said illuminated surface,
- a color video camera provided with at least one optoelectrical semiconductor matrix detector for continuous formation of the optical image of said surface and for repeated production of electrical signals corresponding to said image, as its output quantity, and
- a digital computer for receiving and processing said electrical signals, and for determining quantities corresponding to color and other physical and statistical properties of the froth slurry, with its interfaces for delivering the values of said quantities to central supervision and process control devices.

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PCT REQUEST

49990

Original (for **SUBMISSION**) - printed on 05.05.2000 11:06:50 AM

0 0-1	**For receiving Office use only** International Application No.	PCT/FI 0 0 / 0 0 4 0 0
0-2	International Filing Date	0 5 MAY 2000 (0 5 -05- 2000)
0-3	Name of receiving Office and "PCT International Application"	The Finnish Patent Office PCT International Application
0-4 0-4-1	**Form - PCT/RO/101 PCT Request** Prepared using	PCT-EASY Version 2.90 (updated 08.03.2000)
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	National Board of Patents and Registration (Finland) (RO/FI)
0-7	**Applicant's or agent's file reference**	49990
I	**Title of invention**	METHOD AND APPARATUS FOR MONITORING AND ANALYZING THE SURFACE OF FLOATED MATERIAL
II II-1 II-2 II-4 II-5 II-6 II-7	**Applicant** This person is: Applicant for Name (LAST, First) Address: State of nationality State of residence	 applicant and inventor all designated States NIEMI, Antti Yrjö Liipolantie 5 FIN-02700 Kauniainen Finland FI FI
IV-1 IV-1-1 IV-1-2 IV-1-3 IV-1-4 IV-1-5	**Agent or common representative; or address for correspondence** The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: Name Address: Telephone No. Facsimile No. e-mail	 agent BERGGREN OY AB P.O. Box 16 FIN-00101 Helsinki Finland +358-9-693701 +358-9-6933944 email.box@berggren.fi

PCT REQUEST

49990

Original (for **SUBMISSION**) - printed on 05.05.2000 11:06:50 AM

V	**D signation of Stat s**	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	**AP: GH GM KE LS MW SD SL SZ TZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT** **EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT** **EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT** **OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT**
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	**AE AG AL AM AT AU AZ BA BB BG BR BY CA CH&LI CN CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW**
V-5	**Precautionary Designation Statement** In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
V-6	**Exclusion(s) from precautionary designations**	**NONE**
VI-1	**Priority claim of earlier national application**	
VI-1-1	Filing date	**05 May 1999 (05.05.1999)**
VI-1-2	Number	**991023**
VI-1-3	Country	**FI**
VI-2	**Priority document request** The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	**VI-1**
VII-1	**International S arching Auth rity Chos n**	**Swedish Patent Office (ISA/SE)**

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Original (for **SUBMISSION**) - printed on 05.05.2000 11:06:50 AM

VIII	Check list	number of sheets	electronic file(s) attached
VIII-1	Request	3	-
VIII-2	Description	13	-
VIII-3	Claims	4	-
VIII-4	Abstract	1	49990.txt
VIII-5	Drawings	2	-
VIII-7	TOTAL	23	
	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-9	Separate signed power of attorney	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-17	Other (specified):	Copy of Official Action in FI 991023	-
VIII-18	**Figure of the drawings which should accompany the abstract**	2	
VIII-19	**Language of filing of the international application**	Finnish	
IX-1	**Signature of applicant or agent**		
IX-1-1	Name	BERGGREN OY AB	
IX-1-2	Name of signatory	Leif Nordin	
IX-1-3	Capacity	Patent Agent	

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10-1	**Date of actual receipt of the purported international application**	05 MAY 2000	(05 -05- 2000)
10-2	**Drawings:**		
10-2-1	Received		
10-2-2	Not received		
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**		
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**		
10-5	**International Searching Authority**	ISA/SE	
10-6	**Transmittal of search copy delayed until search fee is paid**		

FOR INTERNATIONAL BUREAU USE ONLY

11-1	**Date of receipt of the record copy by the International Bureau**	30 MAY 2000	30.05.00

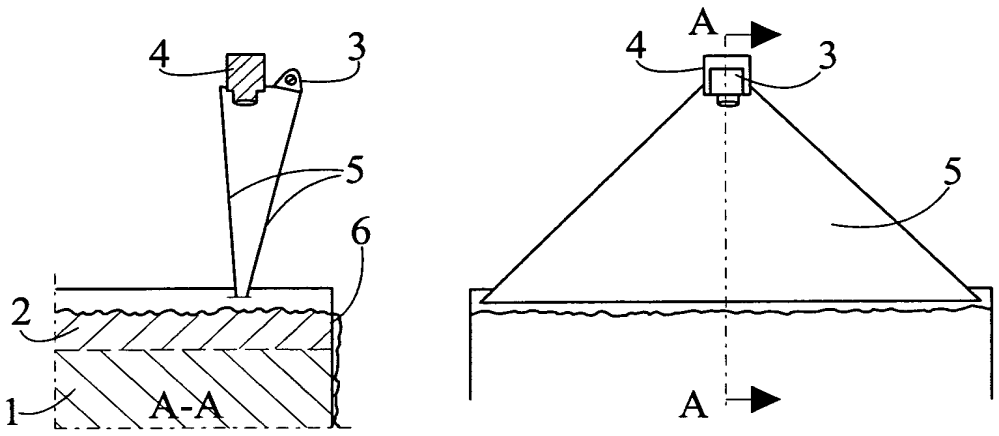

Fig. 1

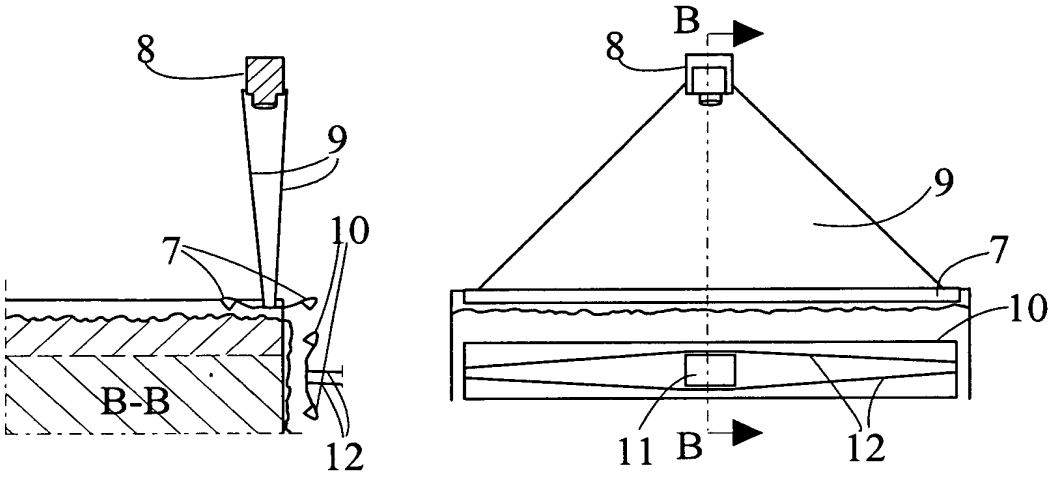

Fig. 2

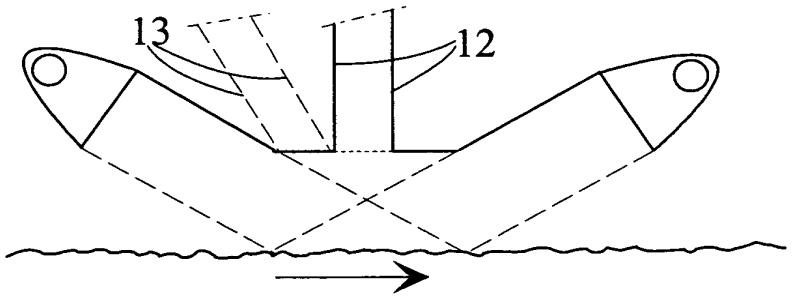

Fig. 3

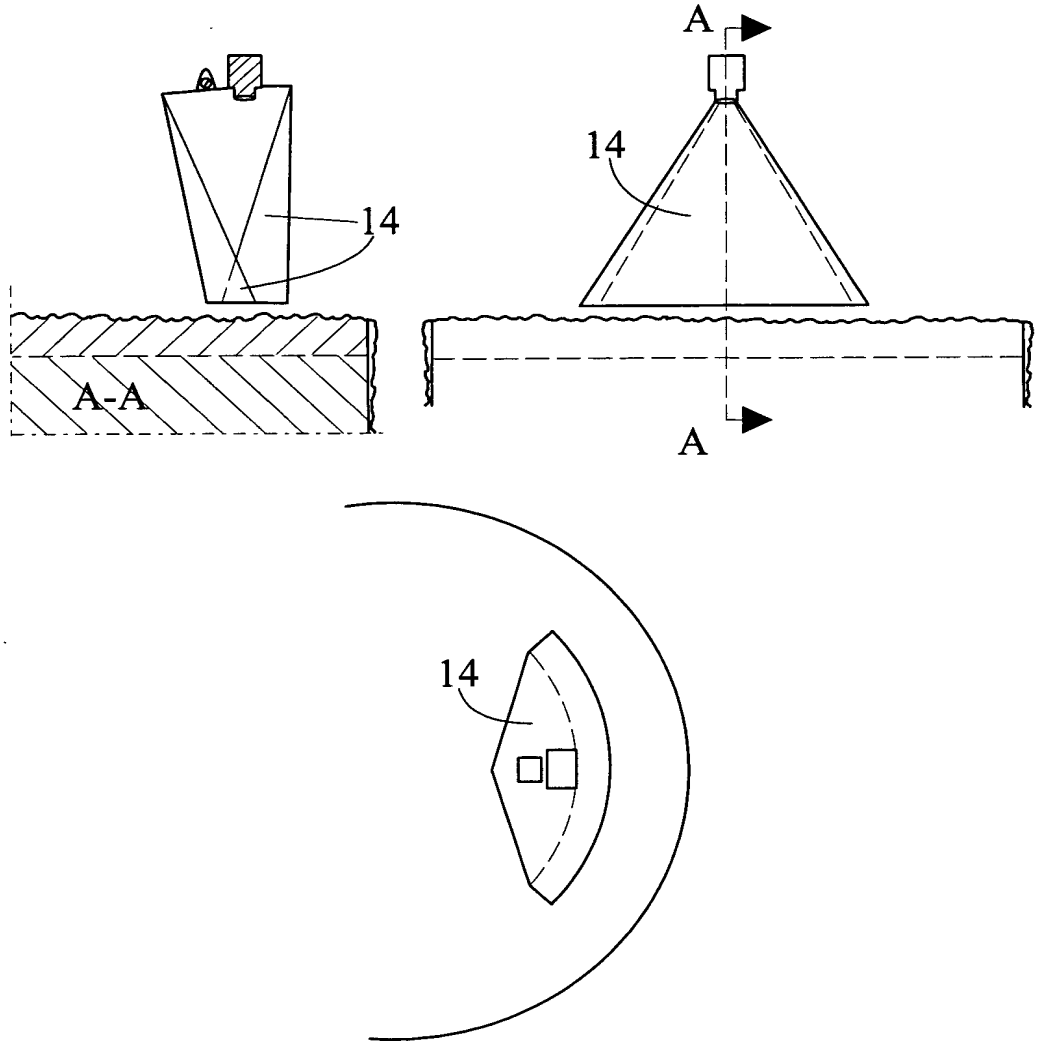

Fig. 4

Menetelmä ja laitteisto vaahdottuneen aineen pinnan valvomiseksi ja analysoimiseksi

Keksinnön yleinen tausta

Halutut arvomineraalit erotetaan vuoriteollisuudessa malmeista usein vaahdottamalla. Tätä toteutetaan läpivirtaustyyppisissä vaahdotuskennoissa, joissa voimakkaasti hämmennettyyn malmijauheen ja veden lietteeseen johdetaan ilmaa. Kemiallisen esikäsittelyn ansiosta arvomineraalin rakeet pyrkivät kiinnitymään selektiivisesti ilmakuplien pinnoille, noustakseen näiden mukana lietteestä tämän pinnalla olevaan vaahtokerrokseen. Samalla tähän kerrokseen nousee muitakin mineraalirakeita ja sekarakeita, joiden vaahdottumistaipumus on heikompi, ja myös palautumista vaahdosta lietteeseen esiintyy. Vaahto valuu jatkuvasti kennon lietereunan yli ränniin tuottaen kennon rikasteen.

Teollisen vaahdotuspiirin lopullinen rikaste muodostuu yksittäisten vaahdotuskennojen rikasteista, jotka on tavallisesti puhdistettu vaahdottamalla ne uudelleen, usein useassakin vaiheessa. Kennon rikasteen arvomineraalipitoisuus on, yhdessä arvomineraalin saannin kanssa, tärkein tekijä, josta sen rikasteen taloudellinen arvo riippuu. Tästä syystä lopullisen rikasteen ja pitkin väliajoin myös yksittäisten kennojen rikasteiden laatua valvotaan ottamalla näytteitä ja analysoimalla ne laboratoriossa. Vaahdottamon lietteitä välittömästi mittaavista instrumenteista on tärkein röntgenfluoresenssianalysaattori, joka useimmiten analysoi lietteistä erotettujen näytevirtojen sisältämän kiintoaineen metallipitoisuuksia. Kalleutensa vuoksi tämä laite ei kuitenkaan sovellu yksittäisen kennon rikasteen analysointiin, vaan se analysoi kennoyhdistelmien tai kokonaisten vaahdotuspiirien yhteisnäytteitä. Tarve yksittäisten vaahdotuskennojen toimintaa tai niiden prosessoimaa materiaalia tuotantolinjassa analysoivan instrumentin kehittämiseen on siten suuri. Tästä syystä on vime aikoina kiinnitetty huomiota myös vaahdotusvaahtoon kohdistuviin mittauksiin.

Vaahdon ulkonäkö kuvastaa herkästi vaahtokerroksen ja koko kennonkin toiminnallista tilaa, sillä kaikki sen sisältämä ja sen kautta kulkeva materiaali saapuu siihen kennon lietetilan kautta. Sen pinta on nähtävissä ja perinteisesti prosessinvalvoja tarkkailee sitä paljain silmin havainnoiden kvalitatiivisesti sen yleiskuvaa ja erityisiä piirteitä, perustaakseen sitten manuaaliset ohjaustoimenpiteensä havaintoihinsa ja päätelmiinsä. Täten hän voi tyypillisesti kuvata vaahtoa esim. suurikuplaiseksi, puuromaiseksi, vetiseksi, kuivaksi, jäykäksi tms., sen värin luonnehtimisen lisäksi.

Vaahdon kvantitatiivinen, instrumentaalinen evaluointi on tullut mahdolliseksi, kun videokameran ja siihen kytketyn, sähköistä kuvasignaalia analysoivan tietokoneen yhdistelmä on tullut käytettäväksi. Eri tutkimusryhmät ovat sittemmin kohdistaneet työnsä vaahdotusvaahdosta otettujen kuvien käsittelyyn, joko määrittääkseen vaahtojen rakenteita yksivärikuvista (esim. Moolman D.W. & al. in Int. J. Miner. Process. 43(1995), 193-208) tai niiden värejä moni-, so. tavallisesti kolmivärikuvista (esim. Oestreich J.M. & al. in Minerals Engineering 8(1995), 31-39) ja näihin tarkoituksiin käytettyjä laitteistoja ohjelmistoineen on sittemmin pyritty myös kaupallistamaan. Tyypillistä mainituille tutkimuksille ja laitteistoille on havaita suorakaiteen muotoista, suurehkoa osaa teollisuuskennon vaahtopinnasta, jonka vaakasuora pinta-ala on tyypillisesti huomattavasti suurempi kuin yksi neliömetri, ja käsitellä mainitunlaista näytepintaa kennon vaahtopintaa edustavana näytteenä.

Mainituissa tutkimuksissa on käytetty tavanomaista puolijohdematriisi-videokameralaitteistoa. US-patentti 4 831 641 puolestaan mainitsee virtaavan suspension analysoinnin mineraalien jalostusteollisuudessa ja tarkemmin kiinteiden partikkelien identifioinnin virtaavassa prosessifluidissa, erittelemättä puolijohdematriisi- ja puolijohderivikameraa toisistaan. Vaahdotusvaahtoa se ei mainitse, ja mainitun teollisuuden suspensioilla tarkoitetaan yleensä kaksivaiheisia kiintoaine/nestesuspensioita eikä kolmivaiheista vaahdotusvaahtoa. Kohteen valaisua ei mainitussa patentissa esitetä lainkaan.

Yksittäinen kupla voidaan, kameran ja valonlähteen sijaitessa kennon yläpuolella, erottaa esim. sen laen alueelta voimakkaasti takaisinheijastuvan valon nojalla. Tätä pientä, kirkasta aluetta ympäröi tällöin tummempi vyöhyke. Valaisusta riippuen tummimmat kohdat voivat sijaita kahden kuplan rajalla, mutta kuplia erottavan laakson pohja näkyy usein myös kirkkaana, heijastamansa valon vuoksi, tai tummuusasteen askelmaisena muutoksena. Rajaviivoihin voidaan edelleen perustaa vaahdon rakenneparametrien, kuten keskimääräisen kuplakoon sekä kuplien muodon, tiheyden ja kokojakautuman määritys. Vaahdon liikenopeus puolestaan määritetään peräkkäisiä kuvia toisiinsa vertaamalla. Tavanomaista on myös määrittää kuvatun alueen kirkkausjakautuma ja esittää se histogrammin muodossa. Rakenteen piirteitä voidaan määrittää myös muin statistisin menetelmin, eri tummuusasteen omaavien kuva-alkioiden esiintymistiheyden nojalla. - Vaahdon edellä mainitut, deterministisesti ja statistisesti määräytyvät piirteet ovat esimerkkejä kirjallisuudessa esitetyistä, kuva-analyyttisesti määritetyistä suureista, joita yleensä karakterisoi huomattavan suuri hajonta.

Värivideo- tai väritelevisiokameralla saadaan samanlaisesta kuvakentästä punainen, vihreä ja sininen (RGB-)signaali, joka signaalijoukko tai sitä vastaava, standardimuotoinen komposiittisignaali voidaan käsitellä sellaisenaan tai muuntaa ennen käsittelyä muuhun koodiasuun. Vaahdon värin ja spektrin määrittäminen kärsii suurista eroista vaahdosta peilimäisesti ja diffuusisti kameraan heijastuvan valon intensiteetissä, minkä vuoksi esim. liian korkeat signaalielementit joudutaan poistamaan ennen käsittelyä. Havaittu väri riippuu vaahdon mineraalikoostumuksesta, mutta käytännössä tämän riippuvuuden määrittäminen tuottaa vaikeuksia, mikä edellä mainittujen intensiteettierojen lisäksi johtuu värillisten metallimineraalien pienehköistä värieroista ja muista läsnäolevista, yleensä musta/harmaa/valkoisista mineraaleista ja niiden pitoisuuksien vaihtelusta. Sekä vaahdon rakenteen että värin määrittämiseen vaikuttaa mainittujen kamerainstrumenttien näkökentissä havaittavien suureiden epähomogeenisuus, jota ei aikaisemmin raportoiduissa tutkimuksissa ole otettu huomioon tai joka ei ainakaan ole vaikuttanut niiden menetelmä- eikä laitetekniikkoihin, ja johon jäljempänä palataan.

Mainittuihin, kirjallisuudessa kuvattuihin määrityksiin on käytetty ennestään tunnettuja laskenta-algoritmeja tai matemaattisia menetelmiä, jotka on ohjelmoitu numeerisen laskennan edellyttämään muotoon kuvatun käyttötarkoituksen mukaisesti tai ovat saatavissa kirjasto-ohjelmina (ks. esim. Niemi A.J. & al. in Int. J. Miner. Process. 51(1997), 51-65 ja sen useat viitejulkaisut). Määritystuloksia voidaan hyödyntää vaahdotuksen ohjauksessa, mutta kun niiden riippuvuus vaahdotuksen sisäänmenosuureista ei yleensä ole tarkasti eikä yksikäsitteisesti tunnettu, ovat ohjausta ja säätöä koskevat maininnat jääneet kirjallisuudessa luonnoksen asteelle.

Keksinnön erityinen tausta

Ideaalisesti toimivassa vaahdotuskennossa saapuva ilma jakautuu vaakatasossa akselisymmetrisesti ja kuplat jakautuvat homogeenisesti vielä saavuttaessaan vaahtokerroksen alarajapinnan. Vaahto poistuu tyypillisesti suorakulmaisen suuntaissärmiön muotoisesta kennosta sen yhden reunan yli tai joskus sen kahden vastakkaisen, samansuuntaisen reunan yli. Näin ollen kennon takaosassa (vastaavasti joskus sen keskiosassa) vaahtokerrokseen nousevien kuplien mukanaan tuoma neste ja kiintoaine viipyvät pisimpään matkallaan ylitereunalle ja pois kennosta. Mainittujen komponenttien ja niistä erityisesti muiden kuin vaahdottuvan pääminerаalin määrä tosin vähenee matkalla kuplien särkyessä ja yhtyessä toisiinsa, ja niiden rakeiden joko kiinnittyessä viereisiin tai alempiin kupliin näihin heikommin kiinnittyneitä rakeita syrjäyttäen, tai valuessa kuplien välitse aina lietetilaan asti. Se osa takaosassa nousseesta materiaalista, joka pysyy vaahdon pintakerroksessa, liikkuu aluksi hitaasti ja

sittemmin nopeutuen kohti ylitereunaa. Nopeutuminen johtuu vaahtokerrokseen kaikkialla nousevasta, uudesta materiaalista, joka kiintoaineen selektiivisestä palautumisesta huolimatta antaa vaahdon vapaata reunaa kohti suuntautuvan, jatkuvan impulssin. Täten pintaan tulee jatkuvasti lähempänä ylitereunaa vaahtoon noussutta materiaalia, jonka viipyminen vaahdossa jää lyhytaikaisemmaksi ja puhdistuminen sivukomponenteista vähäisemmäksi. - Vaahtokerrokselle on johdettu teoreettisia malleja (esim. Moys, M.H. in Frothing in Flotation (Editor J.S. Laskowski), Gordon and Breach, UK 1989, 203-228), mutta näistä ei ole voitu tehdä vaahtopinnan mineraalikonsentraatioita koskevia, käytännöllisiä johtopäätöksiä.

Kuvatun prosessin seurauksena vaahtopinnan mineraalikoostumus muuttuu siirryttäessä kohti ylitereunaa. Tämä muuttuminen ja liikenopeuden jatkuva kasvu samassa suunnassa merkitsevät epähomogeenisuustaipumusta myös vaahdon rakenteessa. Teollisen vaahdotusvaahdon epähomogeenisuus onkin todettu alan kirjallisuudessa (Laplante A.R. & al. in Min. Proc. Extr. Met. Rev. 5(1989), 147-168). Sittemmin Niemi A.J. & al. (Int. J. Miner. Process. 51(1997), 51-65) ovat tutkiessaan apatiittivaahdotuskennoja todenneet kennon takaosan vaahdon suhteellisen vaalean värin vastaavan suurempaa apatiittipitoisuutta kuin lähempänä ylitereunaa esiintyvän vaahdon, jonka väriin sivukivenä esiintyvä, punaruskea kiille selvästi vaikuttaa. Vm. kokeellisessa tutkimuksessa on käytetty suurehkon, suorakaiteen muotoisen alan kuvaavaa videokameraa, jonka välittämien kuvien osa-alueiden analysointi on tuottanut mainitun tuloksen.

Voidaan edelleen päätellä, että jonkin, suhteellisen mittavan pinta-alueen sisältämän informaation analysointi yhtenäisenä, ottamatta huomioon sen eri osien välillä esiintyviä väri- ja rakenne-eroja, antaa vain keskimääräisiä tuloksia, joita on kennon tuottaman rikasteen kannalta pidettävä karkeina likimääräistyksinä, ottaen huomioon erityisesti sen, että se osa kuva-alueesta, joka on lähinnä ylitereunaa, on muodostuvan rikasteen kannalta paljon merkitsevämpi kuin kuvatun alueen muut osat tai keskiarvot. Havaintaan vaikuttaa myös kohteen valaisun epähomogeenisuus, joka on sitä suurempi mitä suurempi on mitattavan vaahtopinnan ala ja joka vääristää vastaavasti ilmaisimelle muodostuvaa kuvaa.

Uusi menetelmä ja laitteisto

Prosessin luonteen ja mainittujen tutkimusten nojalla on selvää, että vaahdotusvaahdon pintakerroksen nestefaasin ja eri kiintoainefaasien ikäjakautumat ja liikenopeudet sekä edelleen kiintoaineen mineraalikoostumukset muuttuvat siirryttäessä vaahdon pinnassa kennon takaosasta (keskiosasta) lietereunaa kohti, ja että nämä muu-

tokset vaikuttavat myös pintakerroksen rakenteeseen ja visuaalisesti havaittaviin ominaisuuksiin. Materiaalialkion ikä tarkoittaa tässä aikaa, joka on kulunut sen siirtymisestä vaahtokerrokseen lietetilasta.

Toisaalta ei ole fysikaalisia syitä olettaa, että muutoksia esiintyisi mainitulle liikesuunnalle kohtisuorassa suunnassa, so. siirryttäessä kennon laidalta toiselle samansuuntaisesti ylitereunan kanssa, lukuunottamatta sitä vaikutusta, joka kennon sivuseinillä voi olla välittömässä läheisyydessään vaahdon liikkumiseen ja rakenteeseen. Uuden menetelmän keskeinen piirre on tämän mukaisesti edustavan kuvainformaation hankkiminen vaahtokerroksesta siten, että vaahdon pinnan havainnointi ja havaintotuloksen analysointi kohdistetaan pinnan kapeaan, ylitereunan suuntaiseen kaistaan. Tällaisen kaistan, jonka sisällä vaahto on olennaisesti tasalaatuista, pituus voi olla sama kuin kennon leveys tai tätä pienempi, em. sivuseinävaikutuksen esiintyessä tai muusta, esim. mittauslaiteteknisestä syystä.

Silloinkin kun vaahdotusprosessi toimii stationääritilassa, hetkellinen mittaustulos ja sen nojalla määritetty ominaisuus poikkeavat stationääriarvosta prosessikohinan vuoksi. Esim. jo yksikin, suuri kupla voi olla läpimitaltaan useita prosentteja mittauskaistan pituudesta, joten vaahdon rakennetta, kirkkautta, väriä ja muita ominaisuuksia on määritettävä keskiarvo- ja jakautumasuureina yli kaistan, tavallisesti usean, peräkkäisen havainnon ja liukuvan määrityksen avulla. Tällä tavoin saadut suureet kuvaavat vaahdon ominaisuuksia kussakin valitussa kohdassa paremmin kuin laajemmasta, homogeeniseksi oletetusta mutta todellisuudessa epähomogeenisesta pinnasta määritetyt suureet.

Havaittavan kaistan sijainti riippuu havainnan ja analysoinnin ensisijaisesta tarkoituksesta. Vaahdon rakenteen kannalta se sijoittuu parhaiten ylitereunan edelle, paikkaan, missä ylijuoksusta johtuvat nopeuserot eivät vielä deformoi kuplia. Läheltä ylitereunaa ja tämän jälkipuolelta saatava data taas kuvaa paremmin kennon lopullista rikastetta erityisesti värin ja siten myös mineraalipitoisuuden puolesta. Toisaalta ylitereunan edelle suunnattu havainta ja mittaus voidaan, muiden tulosuureiden kuin kennon syötön mineraalipitoisuuden pysyessä muuttumattomina, periaatteessa kalibroida osoittamaan myös mineraalipitoisuutta.

Havaittavan vaahtokaistan homogeeninen valaisu voi vaatia heijastavien pintojen ja ulkopuolista valoa eliminoivien varjostimien konstruointia käyttötarkoituksen ja käyttöpaikan olosuhteiden mukaisesti, mutta muutoin voi mainitunlaisia määrityksiä suorittava laitejärjestelmä koostua pääosaltaan yhdistelmänä kaupallisesti saatavissa olevista laitteista. Näitä ovat tarkoituksenmukaisen emissiospektrin ja tehon omaa-

vat, vaihto- ja tasasähköiset (AC, DC) lamput, optiset suodattimet, mustavalkoisia ja värikuvia aseteltavin tai kiintein väliajoin ottavat, tavanomaisella linssioptiikalla varustetut puolijohderivikamerat (erityistapauksissa matriisikamerat), tietokoneet, lähinnä mikrotietokoneet, edellisten väliset tiedonsiirtolaitteet ja laitteet mittaus- ja analysointitulosten tulostamiseksi.

Kuvatun menetelmän mukaisen havainnan ja analysoinnin toteuttava laitteisto voi olla esim. US-patentin 4 831 641 mukainen, valosähköisellä rivi-ilmaisimella (engl. linear photodiode array detector) varustettu laitejärjestelmä. Tavanomaisen, sfäärisen optiikan avulla muodostetaan tällöin halutun vaahtokaistan ja sen lähialueen pienennetty kuva siten, että kaista kuvautuu ilmaisimen alueen sisäpuolelle, so. valitaan sopivan polttovälin omaava optiikka ja tämän etäisyys vaahdosta siten, että kuvautuminen toteutuu mainitulla tavalla. Ilmaisimen dimensioista määräytyy samalla havaittavan vaahtokaistan leveys ja sen elementtien lukumäärästä havainnan resoluutio kaistan suunnassa. Ilmaisimen lukutiheys (scanning rate) valitaan tämän jälkeen sopivasti siten, että vaahdon liikkuessa keskimääräisellä nopeudellaan kukin pinnan alkio tulee luetuksi likimäärin yhden kerran. Yhden puolijohdeelementtirivin käsittävien ilmaisimien ohella on saatavissa myös useammasta, rinnakkain sijoitetusta yksirivi-ilmaisimesta koostuvia, integroituja ilmaisimia, joissa rinnakkaisten elementtien signaalit lasketaan yhteen ja jotka antavat vain yhden, sarjamuotoisen lähtösignaalin; aikaisemmin mainitun rivi-ilmaisimen katsotaan edellä ja seuraavassa käsittävän myös nämä ilmaisimet. - Näihin tarkoituksiin on saatavissa teollisuustuotteina rivikameroita (line scan cameras), jotka täyttävät riittävästi optiikalle, havainnan resoluutiolle ja ilmaisimen lukutiheydelle asetettavat vaatimukset. Yksivärikameroiden ohella on saatavilla RGB- ja muita värikameroita, joissa optisen kuvasignaalin värit joko erotetaan suodattimilla tai jaetaan kuvasignaali esim. prismalla komponentteihinsa, jotka sitten ohjautuvat eri puolijohderiviilmaisimiin. Optiseksi signaalialueeksi katsotaan seuraavassa sekä näkyvän että näkymättömän, sähkömagneettisen säteilyn alue, kuten infrapuna- ja ultraviolettivaloalueet sinne asti, minne linssioptiikan ja puolijohdeilmaisimien toimintakyky ulottuu.

Optista kuvasignaalia vastaava sähköinen, diskreetti signaali luetaan ilmaisinelementeiltä pulssisarjasarjamuotoisena ja kukin signaalielementti muunnetaan digitaaliluvuksi, joka on verrannollinen signaalielementin amplitudiin ja siten kuvaelementin harmaustasoon. Tiedon lukeminen, käsittely ja siirto tietokoneen keskusyksikköön prosessointia varten tai tallettaminen muistiin tapahtuvat täten käytännöllisesti esim. sillä tavoin kuin edellä mainitussa patentissa on kuvattu. Vaihtoehtoisesti mittaustie-

to voidaan siirtää myös jatkuvana analogiasignaalina, joka tietokoneen liitäntäyksikössä diskretoidaan ja muunnetaan digitaaliseksi dataksi.

Datan siirto tietokoneen keskusyksikköön ja talletus sen muistiin ohjelmoidaan toteuttamaan niitä ennestään tunnettuja menetelmiä, joita on käytetty rivikameran välittämän tiedon analysointiin ja tulkintaan tarkkailtaessa kiinteitä, mekaanisesti siirrettäviä kappaleita, kuten luokiteltaessa siirtohihnan kuljettamia kiviä kaivosteollisuudessa tai etsittäessä ja todettaessa metallilevyjen pintavikoja valssauksen yhteydessä. Datan käsittely ohjelmoidaan toteuttamaan niitä numeerisia menetelmiä, jotka tunnetaan laajan vaahtopinnan analysoinnista matriisikameran välittämän kuvan nojalla, redusoituina käsittelemään yksidimensioista dataa tai käyttäen niitä kaksidimensioisessa asussaan, siten kuin seuraavassa esitetään.Täten vaahtokaistan harmaushistogrammi saadaan järjestämällä mittaustulokset harmausasteensa mukaan ja kaistan tekstuuria kuvaava funktio esim. Fourierin muunnoksella harmauden vaihtelusta, molemmat useiden mittausten ja analyysien keskiarvofunktioina. Deterministisesti määritettävistä suureista saadaan vastaavasti kuplien leveydet ja leveyden jakautuma.

Kuplien muotojen ja esim. kaksidimensioisten statistisen suureiden määrittämistä varten laaditaan, peräkkäiset kaistasignaalit toisiinsa liittämällä, vaahdon kaksidimensioinen esitys kaistan sijaintikohdalla. Tällainen kuva edustaa stationääritilassa vaahtoa paremmin kuin mikään paljaan silmän tai matriisikameran välittämä, hetkellinen havainto tai näistä johdettu, keskimääräinen kuva. Konstruoitua kaksidimensioista kuvaa voidaan sitten käsitellä niillä menetelmillä, joiden käyttö tunnetaan ennestään matriisikameralla otettujen vaahtokuvien käsittelystä, ja se voidaan esittää monitorilla havaintakaistaa edustavana kuvana vaahdon ominaisuuksien ja näiden muutosten visuaalista tarkastelua ja toteamista varten. - Jos vaahdon nopeus on vaihtelujen alainen, se on kuitenkin tällöin määritettävä erikseen ja otettava huomioon liitettäessä kaistasignaali edelliseen. Tässä voidaan nojautua esim. siihen tosiasiaan, että useimmissa mineraalivaahdoissa pienehköt, leveydeltään kuitenkin vähintäin useita kuvaelementtejä vastaavat kuplat ovat ylhäältä katsottuina pyöreitä. Tällöin voidaan määrittää, ajoittain ja tarpeen mukaan puolijohderivi-ilmaisimen suurempaa pyyhkäisytaajuutta käyttäen, se aikaväli, jonka kuluessa kunkin valitun kuplan etu- tai takareuna ylittää kuvakentän tai tämän reunan. Tämän aikavälin ja kuplan mitatun leveyden, samalla läpimitan, nojalla lasketaan vaahdon hetkellinen, päävirtaussuuntainen nopeus.

Kuva 1 esittää tyypillisen, ensisijaisesti vaahtopinnan rakenteen havaintaan tarkoitetun laitteiston. Lietteen 1 yläpuolella olevan vaahtokerroksen 2 pintaa valaistaan va-

laisimella 3 ja havaitaan rivikameralla 4. Varjostin 5 estää ulkopuolisen valon pääsyn havaittavalle vaahtokaistalle ja kameraan.

Kuva 2 esittää tyypillisen, ensisijaisesti vaahdon värin havaintaan tarkoitetun laitteiston. Vaahtokerroksen pintaa valaistaan lähellä ylitereunaa pitkänomaisilla valaisimilla 7 ja havaitaan väririvikameralla 8. Varjostin 9 ja valaisimet kannatusrakenteineen estävät ulkopuolisen valon pääsyn havaittavalle vaahtokaistalle ja kameraan. - Valuvaa vaahtolietettä valaistaan ja havaitaan ja ulkopuolisen valon pääsy estetään samanlaisilla, olennaisesti vaakasuunnassa kuvaavilla laitteilla 10, 11, 12. Leikkauskuva B-B on rajoitettu siten, että kamera 11 ei näy siinä.

Kuva 3 on suurennettu yksityiskohtakuva vaahdon valaisemisesta kuvan 2 mukaisilla valaisimilla.

Kuva 4 esittää sylinterimäisen vaahdotuskennon vaahtopinnan rakenteen havaintaan tarkoitetun laitteiston. Varjostin 14 estää ulkopuolisen valon pääsyn havaittavalle, kaarevalle vaahtokaistalle ja kameraan.

Kuvan 1 mukaisessa toteutuksessa rivikamera havaitsee kapean, ylitereunan 6 suuntaisen vaahtokaistan. Ensisijaisesti vaahdon rakennetta määritettäessä tätä valaistaan läheltä kameran suuntaa, parhaiten pienikokoisella valaisimella 3. Tällöin eri kuplien erottaminen voidaan perustaa niiden lakialueilta tapahtuviin heijastuksiin. Valaisin heijastimineen, mahdollisine himmentävine pintoineen ja lampunvalintoineen suunnitellaan mahdollisimman tasomaista, havaittavaan vaahtokaistaan tähdättyä valoa antavaksi ja siten valoa ko. tasossa jakavaksi, että se tuottaa homogeenisen valaisun kaistan koko pituudelle. Kapea näkökenttä ja kameran 4 optiikka suojataan ulkopuoliselta valolta levymäisellä varjostimella 5, jonka sisäseinät maalataan minimaalista heijastavuutta silmälläpitäen; vähäisempikin varjostus riittää, jos häiritsevän, ulkopuolisen valon määrä on vähäinen. Kuva 1 esittää edellä kuvattua laitejärjestelyä. Kapeutensa vuoksi laitteisto peittää vain pienen osan vaahdon pinnasta eikä se siten olennaisesti vähennä prosessinvalvojan mahdollisuuksia tarkkailla vaahtoa visuaalisesti.

Kuvan 1 valaisu- ja kuvausjärjestelyä voidaan käyttää myös vaahdon värin määrittämiseen, mutta paremmin tähän tehtävään soveltuu vaahtopinnan valaisu matalassa kulmassa tai matalalla kulma-alueella, jotta vältetään suuret erot kuplien erisuuntaisten pintojen vastaanottamassa ja heijastamassa valossa ja siten mm. kuplien huipuilta tapahtuvat, kirkkaat heijastukset. Kuva 2 esittää tämän mukaista laitteistoa, jossa valaisimet 7 on sijoitettu havaintasolan juureen, sen ulkopuolelle kuvan 3 selventä-

mään tapaan. Ne antavat homogeenisesti jakautunutta valoa pääasiassa heijastimen symmetriatason mukaisessa, pitkänomaiseen valaisimeen nähden kohtisuorassa suunnassa valittuun, parhaiten vaahdon ylijuoksun lähellä sijaitsevaan vaahtokaistaan. Varjostin 9 on kuvan 1 varjostimen kaltainen ja väriviivakamera 8 on sijoitettu samalla tavoin kuin kuvan 1 kamera, joten ne tuottavat samat edut kuin edellä mainittiin. Pystysuunnan sijasta laitteisto voidaan suunnata myös kaltevasti, esim. siten, että se on kohtisuorassa ylitereunan ylittävän materiaalin pintaan nähden, tai vaakasuorasti valaisemaan ja havaitsemaan kennon ylitereunalta valuvan vaahtolietteen kapeaa kaistaa (kuvan 2 vaihtoehtoiset komponentit 10, 11, 12 ovat tällöin samat kuin em. komponentit 7, 8, 9). Valaisu- ja havaintalaitteiston sijoittamiseen vaikuttaa olennaisesti vaahdon kuplien särkyminen ylitereunan luona ja sen jälkeen, virtauksen kiihtyessä ja hydrodynaamisten rasitusten kasvaessa nopeasti. Vaahdon eri kerroksista peräisin olevien kuplien särkyessä liete myös sekoittuu, joten havaittavan näytteen edustavuus vaahtolietteen värin ja siten rikasteen pitoisuuden ilmaisijana paranee, erityisesti ylitereunan ylityksen jälkeen. Valvonnan kohdistuessa ensisijaisesti väriin jää rakenteen kuvaaminen toisarvoiseksi, minkä vuoksi, ja esim. haluttaessa samalla pienentää laitteiston kennon ulkopuolelta vaatiman tilan tarvetta, kamera ja varjostin voidaan suunnata kaltevasti kohteeseen, erityisesti valuvan vaahtolietteen pintaan nähden, valaisun suuntauksen pysyessä pintaan nähden ennallaan. Tämä kameran ja varjostimen suuntausvaihtoehto edellä mainitun varjostimen 12 ja kameran 11 suuntaukseen nähden ilmenee kuvan 3 esittämän, vaihtoehtoisen varjostimen 13 juuriosan suuntauksesta. - Ylitereunalta valuvan vaahdotustuotteen optisen kuvan muodostamiseksi ja tosiaikaiseksi analysoimiseksi ei tiettävästi ole aikaisemmin esitetty mitään menetelmää eikä laitejärjestelyä.

Ensisijaisesti vaahdon rakennetta koskevassa sovellutuksessa kuvattu järjestelmä sijaitsee ylitereuna-alueen edellä havaiten deformoitumatonta vaahtopintaa sen rakenteen määrittämiseksi valitussa kaistassa. Sen antama tieto edustaa yksikäsitteisesti mainittua rakennetta, koska kennon toimiessa tasaisesti kaistan kaikkien suureiden keskiarvot ovat muuttumattomat, vaikka hetkelliset arvot vaihtelevatkin satunnaisesti. Tätä vastoin ennestään tunnettujen, matriisikameraa (tyypillisesti esim. 512 sensorielem. x 512 sensorielem.) vaahdon kuvaamiseen käyttävien järjestelmien antama tieto ei ole samalla tavoin edustavaa, sillä ne eivät ota huomioon kuvaamansa laajan, kaksidimensioisen vaahtopinnan epähomogeenisuutta. Lisäksi kapea kaista on, erityisesti vaahdon väriä määritettäessä, helposti valaistavissa homogeenisesti, toisin kuin laaja pinta. Edelleen rivikamera on matriisikameraa halvempi ja sen tuottaman datan käsittelyn tarvitsema ohjelmisto yksinkertaisempi kuin matriisikameran ta-

pauksessa. Uusi menetelmä ei myöskään olennaisesti rajoita vaahdon pinnan visuaalista tarkkailua.

Toisessa, vaahdon väriä koskevassa sovellutuksessa kuvattu järjestelmä mittaa värisuuretta, joka tulkittuna konsentraatiosuureeksi on suhteessa kiintoaineen mineraalipitoisuuteen. Tällöin käytetään väririvi-ilmaisimia ja -kameraa, joiden käytölle on ominaista, että saatavat värisignaalit perustuvat kulloinkin valittuun, kapeaan vaahtokaistaan. Värien määritys suoritetaan värisignaalikomponenttien amplitudien nojalla. Valaisun homogeenisuuden, vaahto- tai lietepinnan visuaalisen tarkkailtavuuden, laitteiston taloudellisuuden ja ohjelmoinnin helppouden osalta uusi värihavaintajärjestelmä on edullisempi kuin vastaava, matriisikameraa käyttävä järjestelmä, jonka käyttöä vaahtolietteen havaintaan kennon etuseinällä ei, kuten edellä on mainittu, tunneta ennestään. - Valittua, yksittäistä värisignaalikomponenttia voidaan lisäksi käyttää, musta/harmaa/valkea-signaalin tapaan, vaahdon rakenteen määrittämiseen.

Myös matriisikameralaitteisto voidaan ohjelmoida lukemaan toistuvasti samaa yksittäistä, ylitereunan suuntaista elementtiriviä, jolloin saadaan mittaustietoa kapeasta vaahtokaistasta periaatteessa samalla tavoin kuin rivikamerajärjestelmää käytettäessä. Tällaista matriisikameran käyttöä vaahdotusvaahdon havaintaan ja analysointiin ei kuitenkaan ole raportoitu eikä tiettävästi tähän mennessä sovellettu. Sitä tällä tavoin käytettäessä saavutettaisiin kuitenkin homogeeninen valaisutulos, hyvä suojaus ulkoisia valonlähteitä vastaan ja samalla hyvä visuaalinen tarkkailtavuus vain käyttämällä samanlaista, uuden keksinnön mukaista valaisua ja varjostusta kuin tämän selityksen ja kuvan 1 yhteydessä on kuvattu. Vaikka matriisikamerankin käyttö näin toteutettuna kuuluu keksinnön piiriin, olisi teknisesti epäjohdonmukaista käyttää mitään etua saavuttamatta kapean, suoran kaistan havaintaan teknisesti monimutkaisempaa matriisi-ilmaisinta, yksinkertaisemman, helppokäyttöisemmän ja keksinnön piiriin myös kuuluvan rivikamerajärjestelmän sijasta.

Kuvatulla uudella menetelmällä määritetyt, vaahdon fysikaalisia ominaisuuksia vastaavien suureiden arvot ja niistä laskennollisesti johdettujen suureiden arvot tulostetaan numerollisesti ja graafisesti monitoreilla ja rivi-, laser- ym. kirjoittimilla prosessin valvojalle tiedoksi ja prosessin ohjauksessa käytettäväksi. Ne voidaan tulostaa myös digitaali- ja analogiamuotoisina vaahdotusprosessin sisäänmenoja ohjaaviin säätäjiin ja toimilaitteisiin prosessin automaattista ohjaamista ja säätämistä varten. Toimilaite ja prosessin tulosuure, joita tällä tavoin tulostetut suureet ohjaavat, määräytyvät säädettävän prosessin ominaisuuksista ja valitaan siten, että mittaustietoa tai sen muutosta vastaava, korjaava vaikutus saadaan aikaan, ja erityisesti

takaisinkytketyn säädön tapauksessa mitattu poikkeama asetusarvosta eliminoiduksi. Vaahdotuspiiri tai -kenno on jo prosessiteknisistäkin syistä varustettu tällaisilla, ainakin manuaalisilla toimilaitteilla ja vastaavia laitteita automaattista säätöä varten on saatavissa. Mainittu asetusarvo on puolestaan se mitatun suureen arvo, joka tällä suureella halutaan mittauspaikassa olevan nimelliskäyttöolosuhteissa. Se voi olla vakio, mutta sitä voidaan myös asetella manuaalisesti tai automaattisesti riippuen käyttöolosuhteista, kuten prosessoitavan malmin arvomineraalipitoisuudesta. Uutta piirrettä vaahdotuskennon automaattisessa säädössä merkitsee uusi, paikallisesti kiinteän vaahtokaistan havaintaan perustuva säädön mittaussuure, joka kuvaa prosessia yksikäsitteisemmin kuin aikaisemmat menetelmät ja laitejärjestelmät ja joka tästä syystä tuottaa, prosessin sisäänmenoja ohjaaviin elimiin tulostettuna, niitä paremman säätötuloksen.

Keksintöä edellä kuvattaessa on sen ensisijaisena sovellutuskohteena ollut tavanomainen vaahdotuskenno, jonka ylitereuna on suora tai ylitereunat suorat. Teollisuudessa esiintyy myös tästä poikkeavia vaahdotuskennoja ja esim. vaahdon kaapijoilla varustettuja kennoja, mutta uusi menetelmä on johdonmukaiset muutokset tehden sovellettavissa myös niihin. Esimerkkinä tällaisesta, keksinnön toisentyyppisestä toteutuksesta esitetään seuraavassa sen soveltaminen lieriömäiseen vaahdotuskennoon, jonka ylitereuna on vaakasuora ympyrä tai ympyrän osa.

Kuvan 4 esittämässä, sylinterimäisessä vaahdotuskennossa havaittava kaista on johdonmukaisesti aikaisemman kanssa kahden, kennon kanssa samankeskisen ympyränkaaren rajoittama vaahtopinnan kaareva alue, joka täten on kennon säteen suunnassa aina ylitereunan suuntainen ja muotoinen. Sen suurempi säde on normaalisti ylitereunan säteen pituinen tai tätä lyhyempi. Kaistan valittu, edustavaksi katsottu pituus määrää sen osuuden täydestä ympyrästä eli sitä vastaavan keskuskulman, eikä aiemmin kuvatun toteutuksen yhteydessä mainittu sivuseinävaikutus ole nyt läsnä.

Erityisesti vaahdon rakennetta määritettäessä kaistan valaisu ja kuvaus voidaan suunnata tapahtuviksi kaistan reunojen kautta kulkevien kartiopintojen välitse, jolloin kaistan pituus määrää tarvittavan kartiopinnan osan leveyden. Tämä osa kapenee suoraviivaisesti vastaavan kartion kärkeen, joka suoran kartion tapauksessa sijaitsee kennon yläpuolella, keskiakselilla. Usein on kuitenkin edullisempaa sijoittaa kärjet keskiakselin ulkopuolelle, kaistan rajoittaman sektorin akselin yläpuolelle, sopivalle korkeudelle, jolloin vastaavat pinnat ovat vinojen kartiopintojen osia. Kamera voi esim. sijaita vertikaalisesti sektorin akselin sen pisteen yläpuolella, joka on koko kaistapinnan akselinsuuntainen mediaanipiste. Ulompi pinta voi tällöin käytännöllisesti olla, edellä tarkoitetun vinokartiopinnan osan sijasta, kaistan ulkoreu-

nan määräämän, pystysuoran sylinteripinnan osa, ja vain sisempi vinokartiopinnan osa. - Mainitut kartio- ja sylinteripinnat 14 niitä yhdistävine sivupintoineen estävät ulkopuolisen, vaahdon havaintaa häiritsevän valon pääsyn kuvattavalle alueelle ja kameraan.

Pienikokoinen valonlähde ja kamera sijoitetaan edellä mainittujen tai tarkoitettujen kartioiden kärkien välille tai lähelle tätä paikkaa. Käyrä vaahtokaista kuvataan kameraoptisesti esim. puoliympyrän kaaren muotoiselle, kapealle, puolijohde-elementeistä koostuvalle sensorille, jollaisia on valmistettu erityistarkoituksiin. Kameran etäisyys ja polttoväli asetetaan tällöin siten, että halutun kaistan kuva osuu koko pituudeltaan mainitulle sensorille tai kaistan pituutta vastaavalle sensorin osalle. Diskreetti, sähköinen kuvasignaali luetaan ja tulkitaan tämän jälkeen siten kuin lineaarisen rividetektorin tapauksessa on aiemmassa paikassa esitetty.

Jos ylitereuna ei ole suora, voi sopivan kaarevuuden ja elementtilukumäärän omaavan sensorin löytyminen osoittautua vaikeaksi. Tästä syystä ja myös kuvan kohdistamisen yksinkertaistamiseksi voi tavanomaisen puolijohdematriisisensorin ja -kameran käyttö osoittautua tällaisessa tapauksessa edulliseksi, vaikka sen käyttö suoran vaahtokaistan havaintaan osoitettiin edellä, suorareunaisen vaahdotuskennon tapauksessa, teknisesti epäjohdonmukaiseksi rivikameran käyttöön nähden. Käytettäessä nyt matriisikameraa esim. sylinterinmuotoisen kennon vaahtopinnan havaintaan vastaa kapeaa, ylitereunan suuntaista ja muotoista kaistaa matriisisensorilla samanmuotoinen joukko sensorielementtejä, jotka muodostavat yhtenäisen ketjun. Vastaavan, sähköisen elementtijoukon rajaaminen ja erottaminen saatavasta, digitaalisesta kuvasignaalista ovat kuvankäsittelyä tuntevan ammattimiehen johdonmukaisesti suoritettavissa.

Vastaavasti vaahdon värin määrittäminen tapahtuu sylinterikennon tapauksessa sopivimmin käyttäen tavanomaista värimatriisisensoria ja -kameraa samalla tavoin kuin yksivärikameran osalta edellä esitettiin, huomioonottaen sähköisten värisignaalien käytön osalta ne erityispiirteet, jotka esitettiin aiempana koskien väriviivakameran käyttöä suorareunaisen kennon vaahdon värin havaintaan. Myös tällöin tarvittava, homogeeninen valaisu matalassa kulmassa toteutetaan analogisesti suoran vaahtokaistan valaisun kanssa. Koska kuitenkin kartio- tai sylinteripinnan käyrää reunaa seuraavan valaisun toteuttaminen voi tällöin aiheuttaa vaikeuksia, voidaan se tuottaa likimääräisesti, jakamalla se usealle suoralle valaisimelle pitkin reunaa. Vastaavasti kartio- ja sylinteripinnat voidaan jakaa yhtä moneen, tasopintaiseen ja suorareunaiseen segmenttiin, etäännyttäen samalla vastakkaisia pintoja toisistaan siten, että riittävä homogeenisuus säilyy eikä kohdekaista joudu osittainkaan varjoon.

Kaarevan vaahtokaistan kuvan tultua muodostetuksi ja siirretyksi tietokoneeseen edellisissä kappaleissa kuvatulla tavalla, siihen voidaan soveltaa niitä analyysimenetelmiä, jotka esitettiin aiempana, suuntaissärmiön muotoisen vaahdotuskennon yhteydessä. Esim. kaksidimensioinen kuva vaahdosta kaistan sijaintikohdalla muodostetaan aikaisemmin esitettyä vastaavalla tavalla, jolloin samalla voidaan oikaista kukin yhteenliitettävä kaista suoraksi sen elementtien amplitudilukema-arvoja muuttamatta. Tällöin syntyvä kuva muodostuu suorakulmaiseen koordinaatistoon, mikä on useimpien, numeeristen analyysimenetelmien käytön kannalta edullista.

Kennon sylinteripintaa pitkin valuvan vaahtolietteen osalta sekä valaisu että kuvaus toteutetaan kuvan 2 mukaisilla yksiköillä, jotka konstruoidaan riittävän kapeiksi ja asennetaan vieretysten, samalle korkeudelle ja kukin samalle etäisyydelle sylinteripinnasta, niin että riittävän homogeeninen valaisu ja geometrisesti riittävän oikea kuva saavutetaan. Puolijohde-väririvisensorien antamat signaalit yhdistetään sitten yksikköjen yhteisessä tietokoneessa, riittävän mittavaa vaahtolietevirtaa edustavan väri-informaation tuottamiseksi. Hyvissä olosuhteissa, kun valuva vaahtoliete on vaakasuunnassa homogeenista yli sylinteripinnan, yksikin valaisu- ja havaintayksikkö voi riittää antamaan edustavan väri-informaation.

Samalla tavoin kuin yllä esitetyssä toteutuksessa, uuden keksinnön katsotaan kattavan esitetyn menetelmän sovellutukset muihin, rakenteeltaan yksityiskohdissa poikkeaviin vaahdotuslaitteisiin, joihin sen soveltaminen on edellä esitetyn nojalla alan tuntevalle ammattilaiselle ilmeistä. Samoin esitetyt rakenteet ja instrumentit halutun valaisun ja havainnan tuottamiseksi on ymmärrettävä esimerkeiksi, jotka kattavat myös sellaiset laitteet, jotka toisenlaisissa käyttökohteissa ovat ammattimiehelle luonnollisia vaihtoehtoja. - Keksinnön mukaisen laitteiston taloudellisuus ja tekninen yksinkertaisuus tekevät sen käytön, odotettavissa olevan rikasteen laadun paranemisen huomioon ottaen, edulliseksi laajemman vaahdotusjärjestelmän ja koko vaahdottamon monissa, jopa kaikissa kennoissa. Teknistaloudellisen lisäedun tuottaa tällöin kuvatiedon käsittelyn keskittäminen siten, että usean kameran välittämät signaalit käsitellään yhteisessä tietokoneessa tai yhteisissä tietokoneissa ja määritetyn datan tulostus keskitetään tarpeen mukaan yhteisiin esityslaitteisiin ja laajempaa vaahdotusjärjestelmää ohjaaviin laitteisiin.

Patenttivaatimukset

1. Menetelmä vaahdottuneen aineen pinnan valvomiseksi ja analysoimiseksi, jolloin mainitusta pinnasta muodostetaan jatkuvasti optinen kuva, joka toistuvasti muunnetaan optosähköisesti sähköisiksi signaaleiksi, jotka luetaan, siirretään ja käsitellään digitaalisesti mainitun aineen ja pinnan fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi ja tulostamiseksi, **tunnettu** siitä, että mainittu kuva optosähköisesti muunnettaessa rajataan kapeaksi suorakaiteeksi ja jaetaan riviksi kuvaelementtejä, että ilmaistujen, sähköisten signaalien elementit vastaavat yksittäin mainittuja kuvaelementtejä ja että mainittua, kapeaksi suorakaiteeksi rajattua kuvaa optisesti vastaava, samanmuotoinen alue mainitulla pinnalla on homogeenisesti valaistu ja vaahdotuskennon ylitereunan suuntainen,

2. Laitteisto vaatimuksen 1 mukaisen menetelmän toteuttamiseksi, käsittäen yhdistelmänä

- vähintäin yhden valonlähteen (3) ja optiset komponentit vaahdottuneen aineen pinnan valaisemiseksi sekä varjostimen (5) ulkopuolisen valon pääsyn estämiseksi,

- kameran (4) optisen kuvan jatkuvaksi muodostamiseksi mainitusta pinnasta ja tätä kuvaa vastaavien, sähköisten signaalien toistuvaksi tuottamiseksi lähtösuureenaan ja

- digitaalisen tietokoneen mainittujen signaalien vastaanottamiseksi ja käsittelemiseksi ja vaahdon fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi, liitäntöineen mainittujen suureiden arvojen tulostamiseksi keskusvalvonta- ja prosessinohjauslaitteisiin.

tunnettu siitä, että mainittu kamera (4) on puolijohderivi-ilmaisimen käsittävä puolijohderivikamera, joka tuottaa mainitut sähköiset signaalit vaahdottuneen aineen (1, 2) pinnan kapean, ylitereunan (6) suuntaisen kaistan kuvan nojalla, ja että mainitut vähintäin yksi valonlähde (3), optiset komponentit ja varjostin (5) tuottavat homogeenisen valaisun läheltä kameran suuntaa mainitulle kaistalle.

3. Menetelmä vaahdotusvaahdon pinnan valvomiseksi ja analysoimiseksi, jolloin mainitusta pinnasta muodostetaan jatkuvasti optinen kuva, joka toistuvasti muunnetaan optosähköisesti sähköisten signaalien joukoiksi, jotka luetaan, siirretään ja käsitellään digitalisesti mainitun vaahdotusvaahdon ja pinnan väriä ja muita fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi ja tulostamiseksi, **tunnettu** siitä, että mainittu kuva optosähköisesti ilmaistaessa rajataan kapeaksi suorakaiteeksi ja jaetaan eri värikomponentteja edustaviksi joukoiksi riveittäin järjestet-

tyjä kuvaelementtejä, jolloin mainittujen rivien lukumäärä on enintään sama kuin eri värikomponenttien lukumäärä, että ilmaistut sähköisten signaalijoukkojen elementit vastaavat yksittäin mainittuja kuvaelementtejä ja ilmaistut sähköiset signaalijoukot mainittuja, eri värikomponentteja edustavia joukkoja kuvaelementtejä ja että mainittua, kapeaksi suorakaiteeksi rajattua kuvaa optisesti vastaava, samanmuotoinen alue mainitulla pinnalla on homogeenisesti valaistu ja vaahdotuskennon ylitereunan suuntainen.

4. Menetelmä vaahdotuskennon ylitereunalta valuvan vaahtolietteen pinnan valvomiseksi ja analysoimiseksi, jolloin mainitusta pinnasta muodostetaan jatkuvasti optinen kuva, joka toistuvasti muunnetaan optosähköisesti sähköisten signaalien joukoiksi, jotka luetaan, siirretään ja käsitellään digitalisesti mainitun vaahtolietteen ja pinnan väriä ja muita fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi ja tulostamiseksi, **tunnettu** siitä, että mainittu kuva optosähköisesti ilmaistaessa rajataan kapeaksi suorakaiteeksi ja jaetaan eri värikomponentteja edustaviksi joukoiksi riveittäin järjestettyjä kuvaelementtejä, jolloin mainittujen rivien lukumäärä on enintään sama kuin eri värikomponenttien lukumäärä, että ilmaistut sähköisten signaalijoukkojen elementit vastaavat yksittäin mainittuja kuvaelementtejä ja ilmaistut sähköiset signaalijoukot mainittuja, eri värikomponentteja edustavia joukkoja kuvaelementtejä ja että mainittua, kapeaksi suorakaiteeksi rajattua kuvaa optisesti vastaava, samanmuotoinen alue mainitulla pinnalla on homogeenisesti valaistu ja vaahdotuskennon ylitereunan suuntainen.

5. Laitteisto vaatimuksen 3 tai 4 mukaisen menetelmän toteuttamiseksi, käsittäen yhdistelmänä

- vähintäin yhden valonlähteen (7) ja optiset komponentit vaahdottuneen aineen (1, 2) pinnan valaisemiseksi sekä varjostimen (9) ulkopuolisen valon pääsyn estämiseksi,

- kameran (8) optisen kuvan jatkuvaksi muodostamiseksi mainitusta pinnasta ja tätä kuvaa vastaavien, sähköisten signaalien toistuvaksi tuottamiseksi lähtösuureenaan,

- digitaalisen tietokoneen mainittujen signaalien vastaanottamiseksi ja käsittelemiseksi ja vaahdottuneen aineen väriä ja muita fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi, liitäntöineen mainittujen suureiden arvojen tulostamiseksi keskusvalvonta- ja prosessinohjauslaitteisiin,

tunnettu siitä, että mainittu kamera (8) on optosähköisillä puolijohderivi-ilmaisimilla varustettu värivideokamera, joka tuottaa mainitut, sähköiset signaalit vaahdot-

tuneen aineen pinnan kapean, ylitereunan suuntaisen kaistan kuvan nojalla ja että mainitut vähintäin yksi valonlähde (7), optiset komponentit ja varjostin (9) tuottavat mainitulle kaistalle homogeenisen valaisun, joka kohtaa mainitun kaistan matalassa kulmassa.

6. Menetelmä vaahdotusvaahdon pinnan valvomiseksi ja analysoimiseksi, jolloin mainitusta pinnasta muodostetaan jatkuvasti optinen kuva, joka toistuvasti muunnetaan optosähköisesti sähköisiksi signaaleiksi, jotka luetaan, siirretään ja käsitellään digitaalisesti mainitun vaahdotusvaahdon ja pinnan fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi ja tulostamiseksi, **tunnettu** siitä, että mainituista sähköisistä signaaleista erotetaan ja käsitellään digitaalisesti ne, jotka johtuvat kapeasta, ylitereunan muotoiseksi rajatusta, kuvaelementtien ketjuksi jaetusta kuvasta, että digitaalisesti käsiteltävien sähköisten signaalien elementit vastaavat yksittäin mainittuja kuvaelementtejä ja että mainittua kapeaa, ylitereunan muotoiseksi rajattua kuvaa optisesti vastaava, samanmuotoinen alue mainitulla pinnalla on homogeenisesti valaistu ja joka kohdassaan samalla etäisyydellä vaahdotuskennon ylitereunasta.

7. Laitteisto vaatimuksen 6 mukaisen menetelmän toteuttamiseksi, käsittäen yhdistelmänä

- vähintäin yhden valonlähteen (7) ja optiset komponentit vaahdotusvaahdon pinnan valaisemiseksi sekä varjostimen (9) ulkopuolisen valon pääsyn estämiseksi,

- puolijohdematriisi-videokameran (8) optisen kuvan jatkuvaksi muodostamiseksi mainitusta pinnasta ja tätä kuvaa vastaavien, sähköisten signaalien toistuvaksi tuottamiseksi lähtösuureenaan ja

- digitaalisen tietokoneen mainittujen signaalien vastaanottamiseksi ja käsittelemiseksi ja vaahdon fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi, liitäntöineen mainittujen suureiden arvojen tulostamiseksi keskusvalvonta- ja prosessinohjauslaitteisiin.

tunnettu siitä, että mainittu tietokone on ohjelmoitu erottamaan ja käsittelemään digitaalisesti ne sähköiset signaalit, jotka johtuvat kapeasta, ylitereunan muotoiseksi rajatusta alueesta kuvassa, jonka mainittu kamera (8) muodostaa paikallisesti kiinteästä, kapeasta, ylitereunan (6) muotoisesta vaahdotusvaahdon pinnan alueesta, ja että mainitut vähintäin yksi valonlähde (7), optiset komponentit ja varjostin (9) tuottavat homogeenisen valaisun läheltä kameran suuntaa mainitulle pinnan alueelle.

8. Menetelmä vaahdotusvaahdon pinnan valvomiseksi ja analysoimiseksi, jolloin mainitusta pinnasta muodostetaan jatkuvasti optinen kuva, joka toistuvasti muunnetaan optosähköisesti sähköisiksi signaaleiksi, jotka luetaan, siirretään ja käsitellään digitaalisesti mainitun vaahdotusvaahdon ja pinnan väriä ja muita fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi ja tulostamiseksi, **tunnettu** siitä, että mainituista sähköisistä signaaleista erotetaan ja käsitellään digitaalisesti ne, jotka johtuvat kapeasta, ylitereunan muotoiseksi rajatusta kuva-alueesta, joka optosähköisesti muunnettaessa jaetaan samanmuotoisiksi, eri värikomponentteja edustaviksi ketjuiksi kuvaelementtejä, jolloin mainittujen ketjujen lukumäärä on enintään sama kuin eri värikomponenttien lukumäärä, että digitaalisesti käsiteltävien sähköisten signaalien elementit vastaavat yksittäin mainittuja kuvaelementtejä ja että mainittua kapeaa, ylitereunan muotoiseksi rajattua kuva-aluetta optisesti vastaava, samanmuotoinen alue mainitulla pinnalla on homogeenisesti valaistu ja joka kohdassaan samalla etäisyydellä vaahdotuskennon ylitereunasta.

9. Laitteisto vaatimuksen 8 mukaisen menetelmän toteuttamiseksi, käsittäen yhdistelmänä

- vähintään yhden valonlähteen (7) ja optiset komponentit vaahdotusvaahdon pinnan valaisemiseksi sekä varjostimen (9) ulkopuolisen valon pääsyn estämiseksi,

- puolijohdematriisi-värivideokameran (8) optisen kuvan jatkuvaksi muodostamiseksi mainitusta pinnasta ja tätä kuvaa vastaavien, sähköisten signaalien toistuvaksi tuottamiseksi lähtösuureenaan ja

- digitaalisen tietokoneen mainittujen signaalien vastaanottamiseksi ja käsittelemiseksi ja vaahdotusvaahdon ja pinnan väriä ja muita fysikaalisia ja statistisia ominaisuuksia vastaavien suureiden määrittämiseksi, liitäntöineen mainittujen suureiden arvojen tulostamiseksi keskusvalvonta- ja prosessinohjauslaitteisiin.

tunnettu siitä, että mainittu tietokone on ohjelmoitu erottamaan ja käsittelemään digitaalisesti ne sähköiset signaalit, jotka johtuvat kapeasta, ylitereunan (6) muotoiseksi rajatusta alueesta kuvassa, jonka mainittu kamera (8) muodostaa paikallisesti kiinteästä, kapeasta, ylitereunan muotoisesta vaahdotusvaahdon pinnan alueesta, ja että mainitut vähintäin yksi valonlähde (7), optiset komponentit ja varjostin (9) tuottavat mainitulle pinnan alueelle homogeenisen valaisun, joka kohtaa mainitun pinnan alueen matalassa kulmassa.

(57) Tiivistelmä

Erotettaessa vaahdottamalla eri mineraaleja malmeista on tunnettua valvoa vaahdotuskennossa ylimpänä olevan vaahtokerroksen pinnan laajahkoa osaa videokameralla, jonka signaalit analysoidaan tietokoneessa vaahdon rakenteen ja värin selvillesaamiseksi. Uusi menetelmä ja laitteisto rajoittavat valvonnan ja analysoinnin kohdistuviksi vaahdottuneen aineen pintaan kiinteässä, kapeassa, kennon ylitereunan (6) suuntaisessa kaistassa, jossa sen kautta kulkeva ainepinta on jatkuvuustilassa homogeeninen ja joka siten esittää jatkuvuustilaa keskimäärin edustavan, uusiutuvan näytteen pinnasta ko. paikassa. Tähän kaistaan suunnataan homogeeninen valaisu, joka voi kohdata kaistan eri kulmissa sen mukaan, määritetäänkö ensisijaisesti kohteen väriä vai rakennetta. Kaistan kuva muodostetaan ja muunnetaan toistuvasti lukevalla puolijohderivikameralla (8) sähköisiksi yksi- tai monivärisignaaleiksi, joista aineen rakenne- ja värisuureet määritetään tietokoneessa. Valvonta ja analysointi ovat kohdistettavissa sekä vaahtokerroksen pintaan että kennon ylitereunalta valuvan vaahtolietteen pintaan.

Kuva 2

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

BERGGREN OY AB
P.O. Box 16
FIN-00101 Helsinki
FINLANDE

Berggren Oy Ab
22 -09- 2000

Date of mailing (day/month/year) 13 September 2000 (13.09.00)	
Applicant's or agent's file reference 49990	**IMPORTANT NOTIFICATION**
International application No. PCT/FI00/00400	International filing date (day/month/year) 05 May 2000 (05.05.00)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 05 May 1999 (05.05.99)
Applicant NIEMI, Antti	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by th International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
05 May 1999 (05.05.99)	991023	FI	14 Augu 2000 (14.08.00)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Aino Metcalfe

Telephone No. (41-22) 338.83.38

WO 00/68672
PCT/FI00/00400

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
BERGGREN OY AB
P.O. Box 16
FIN-00101 Helsinki
FINLANDE

Berggren Oy Ab
24 -11- 2000

Date of mailing (day/month/year) 16 November 2000 (16.11.00)	
Applicant's or agent's file reference 49990	**IMPORTANT NOTICE**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/FI00/00400	05 May 2000 (05.05.00)	05 May 1999 (05.05.99)

Applicant
NIEMI, Antti

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AG,AU,DZ,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CR,CU,CZ,DE,DK,DM,EA,EE,EP,ES,FI,GB,GD,
   GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,
   NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   16 November 2000 (16.11.00) under No. WO 00/68672

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 49990	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/FI 00/00400	International filing date *(day/month/year)* 5 May 2000	(Earliest) Priority Date *(day/month/year)* 5 May 1999
Applicant NIEMI, ANTTI JOHANNES		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] Certain claims were found unsearchable (See Box I).

2. [ ] Unity of invention is lacking (See Box II).

3. [ ] The international application contains disclosure of a nucleotide and/or amino acid sequence listing and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the title,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the abstract,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is:
   Figure No. 2
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00400

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G01N 21/85, B03B 13/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G01N, B03B, B03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CIPRIANO,A.ET AL."EXPERT SYSTEM FOR SUPERVISION OF MINERAL FLOTATION CELLS USING ARTIFICAL VISION" in:Industrial Electronics,1997,ISIE'1997., Proceedings of the IEEE International Symposium on p.149-153 vol.1 7-11 July 1997. see fig.1;p.151, col.1,li.10 - li. 31. --	1-9
X	GUARINI,M.ET AL"A SENSOR FOR ASSESSING THE QUALITY OF MINERAL FLOTATION PROCESS".In:Industrial Electronics,1994.Symposium Proceedings,ISIE'94., 1994 IEEE INTERNATIONAL SYMPOSIUM on p:386 - 391 25-27 MAY 1994. See p.386,col.2, li. 17 -p.387, col.1, li.23 --	1-9

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search	Date of mailing of the international search report
4 Sept 2000	08 -09- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Gunnel Wästerlid/itw Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
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